Study Element Report

HAWAII WATER RESOURCES REGIONAL STUDY

Honolulu, Hawaii

LEVEL B WATER SUPPLY PLANNING
Case Study: Island of Maui

Supplement to
WATER SUPPLY
Study Element Report

Hawaii Water Resources Regional Study
Honolulu, Hawaii

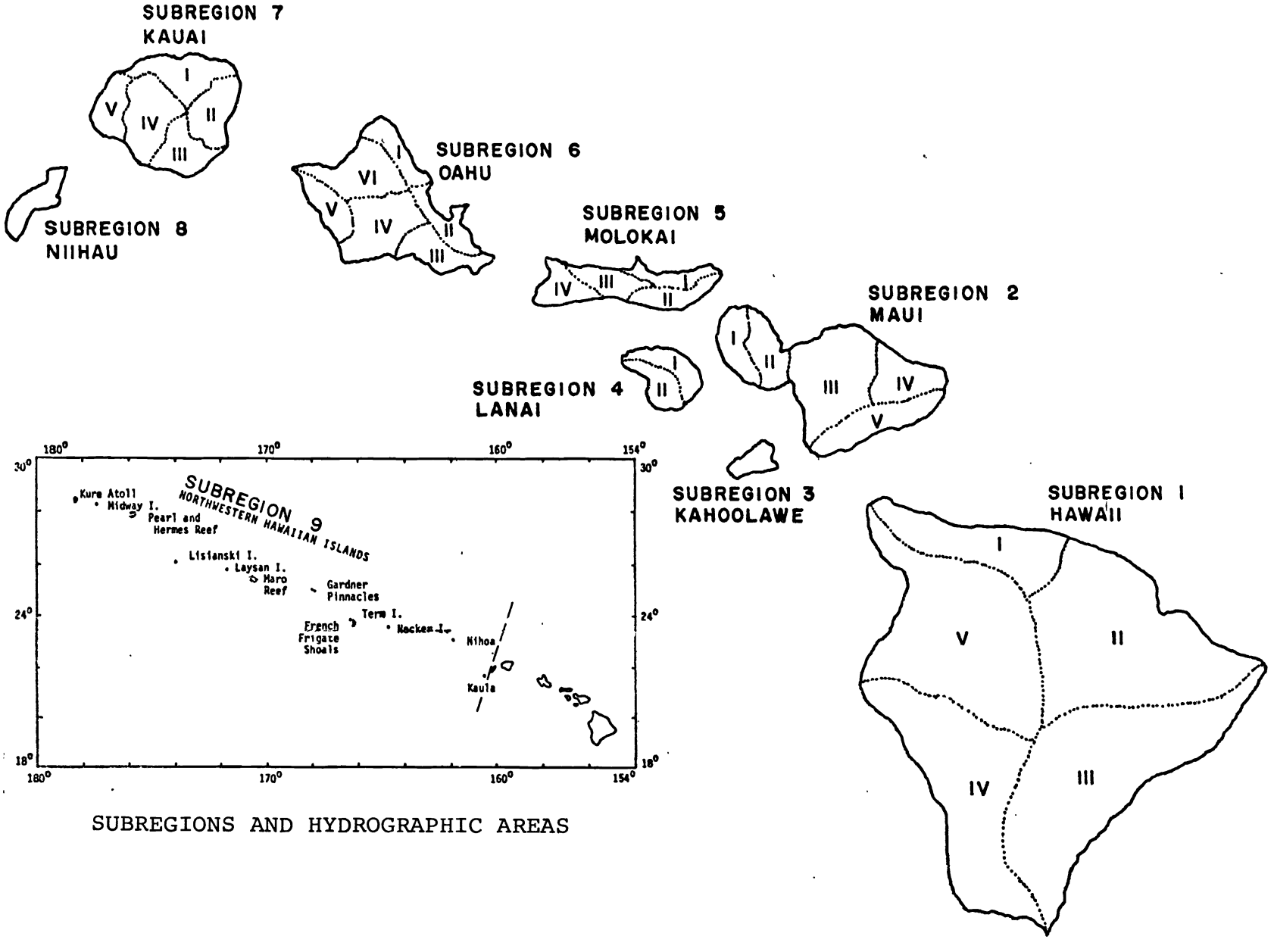
March 1976

PREFACE

Preliminary results of a water supply case study on the Island of Maui were published in April 1975 as Appendix F to the Water Supply Study Element Report.

The case study has been finalized and has been incorporated into the proposed "Guidelines for Regional or River Basin Planning (Level B)" published by the U.S. Water Resources Council for field evaluation in March 1976.

The case study is reprinted herein with its original pagination.



SUBREGIONS AND HYDROGRAPHIC AREAS

SUMMARY LEVEL B STUDY: Outline

The Summary Level B Study is designed to briefly and concisely communicate to the public the results of the water supply study team effort on Maui. It consists of five principal sections:

I Study Initiation

II Study Focus

III Study Results

IV Study Implications

V Study Implementation.

I. Study Initiation

Purpose: To convey to the public the type of problems, concerns and issues that were considered at the beginning of the Level B investigation.

Example: For the water supply effort on Maui problems were identified in five categories:

Demand:	Water demand projections (expected growth) for tourism and agriculture; effects of drip irrigation on agricultural land use and sugar production.
Supply Sources:	Impact of surface water rights and minimum streamflow requirements on water source development.
Demand/Supply Comparisons:	Study of economic and physical feasibility of seasonal storage and groundwater recharge.
Water Supply System:	Develop a "best" plan for water supply and recommend studies to determine appropriate parameters.
Institutional:	Given a "best" plan, develop implementation mechanisms for government and private interests.

II. Study Focus

Purpose: To convey to the public: (1) after a broad listing of problems, the study team narrowed the scope of their investigation to a set of specific study focuses; and (2) the type of questions addressed.

Focus 2

Assess impact of drip irrigation on agricultural land use and sugar production.

- What are the irrigation requirements under drip irrigation?
- How much is groundwater recharged and what is the recovery rate under furrow irrigation?
- What is the sugar production per acre under drip irrigation?

Focus 5

Develop "best" plan for water supply given uncertainty in basic parameters and recommend studies to determine appropriate parameters.

- What sources should be used (high level groundwater, basal groundwater, streamflow, wastewater, saline water, groundwater recharge)?
- How should sources be connected to demand?
- What problems need further investigation?

III. Study Results

Purpose: To convey to the public: (1) the recommendations of the study team for those problems selected as a focus for the study; (2) the type of problems not resolved by the study.

Example: For Focus 2: "Assess impact of drip irrigation on agricultural land use and sugar production" the study team developed a program of investigations that will assure that improved estimates on drip irrigation are available when plans for the period 1985-2000 need to be finalized. The study team did not make any improvements in the available estimates associated with drip irrigation.

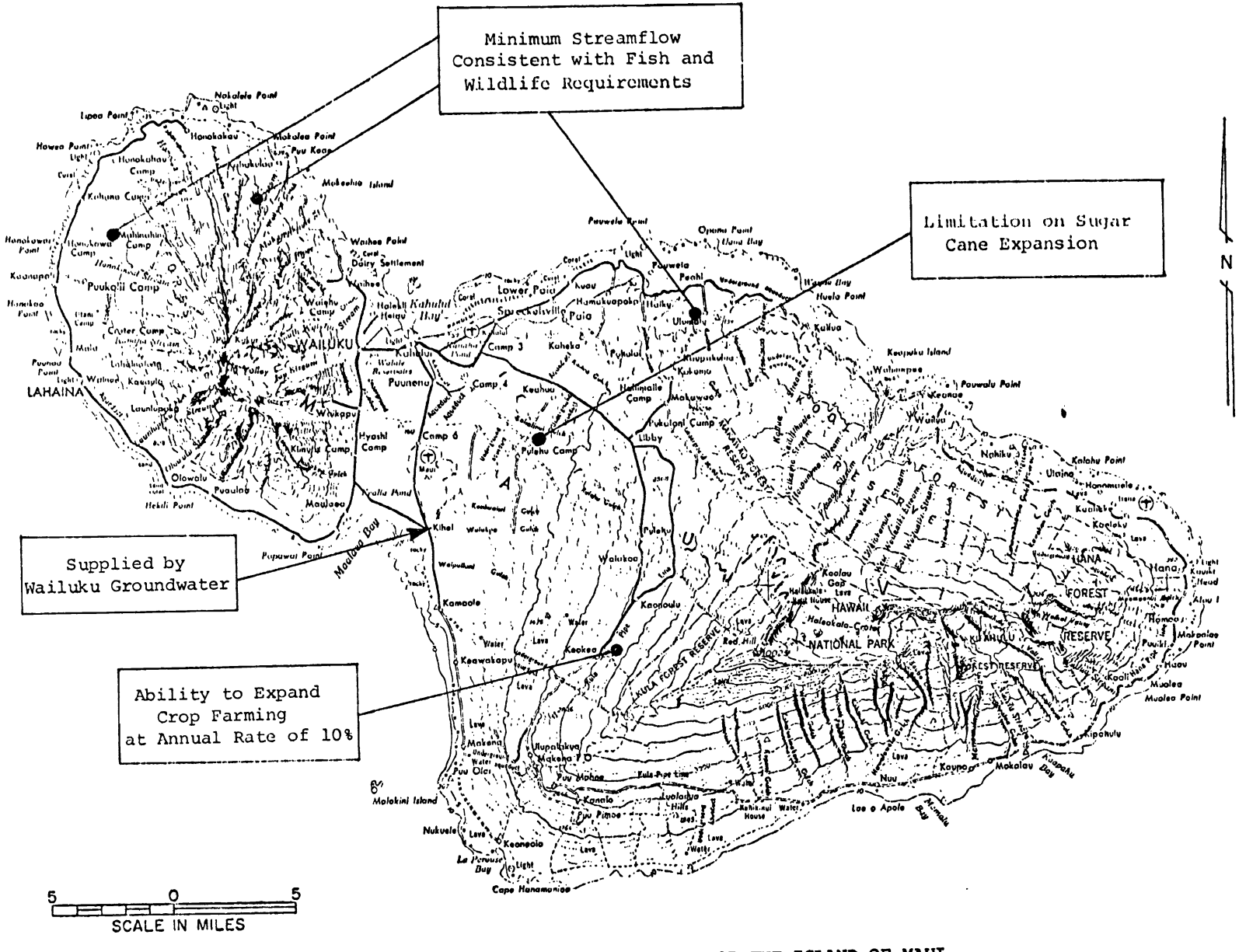
IV. Study Implications

Purpose: To convey to the public the tangible outputs that will result from implementing the study.

Example: For Maui, the main implications for implementing the 1985 water supply plan are indicated on the map on page 273.

V. Study Implementation

Purpose: To convey to the public: (1) the cost associated with implementing the study team's recommendations; and (2) the institutional arrangements and type of projects necessary for the implementation.



KEY IMPLICATIONS OF WATER SUPPLY PLAN FOR THE ISLAND OF MAUI

Example: The total cost of the Level B water supply plan is estimated at $35,000,000. These costs are to be shared between government and private sectors in the following proportions:

Participant	
. Federal	10%
. State	1%
. Local	11%
. Private	78%

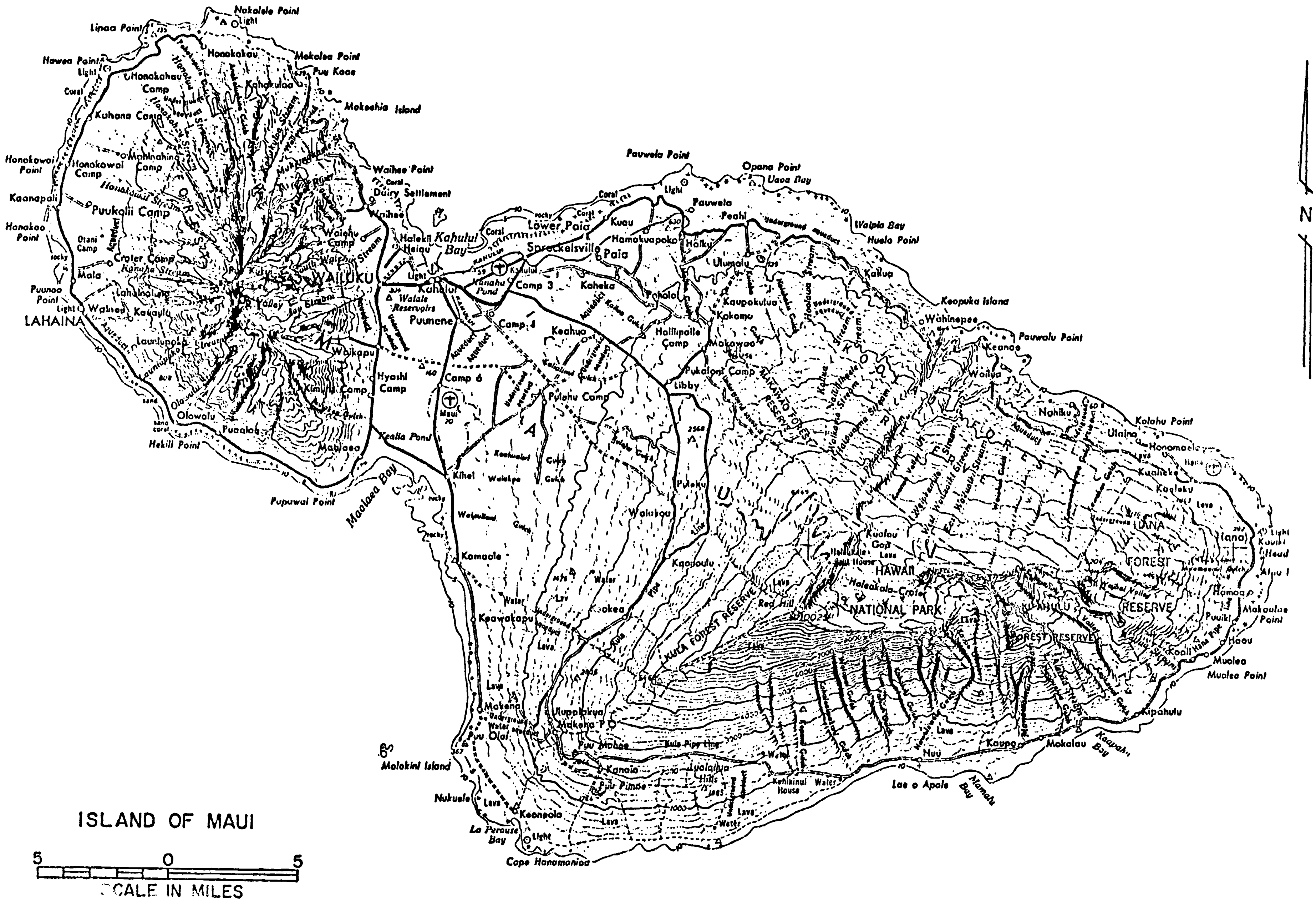
The types of projects are summarized in the following table for the different Level B participants.

Participant	Projects
. Federal	. Environmentally oriented investigations; financial support for actions of the water supply system designed to enhance the environment.
. State	. Contributions to design studies for components of the water supply pland and future investigative studies.
. Local	. Planning, construction, and implementation of domestic water supply system; contribution toward private system development (plans) to facilitate further development of Maui.
. Private	. Planning, construction and installation of water supply system to support sugar and tourist industries.

The assignment of these actions to the various participants is based upon a combination of their (1) expertise, (2) legal authority and jurisdiction, and (3) interest in specific projects as they relate to their own missions.

Section IV-H

Case Study:
Level B Water Supply Planning on Maui
(Hawaii)



GENERAL MAP, ISLAND OF MAUI

H. Case Study: Level B Water Supply Planning on Maui (Hawaii)

This section illustrates the Level B planning process for the water supply element in the Maui subregion of the Hawaii Level B Study. The objective is to demonstrate Level B planning using the Maui case study in order to illustrate to the reader the process and major milestones to be expected. "Milestones" are stressed as they present the type of output to be generated, i.e., in Phase 1 this includes information displays needed to structure the process, key decisions to be made by study manager and team, and, timing for and content of the interaction between the water supply study effort and those responsible for developing plans in other functional areas of the Level B Study. While the material presented focuses on water supply, its applicability extends to other functional areas included in a Level B Study.

The information in this section follows the outline of the planning process given previously, illustrating the four phases as follows: First, for Phase 1, the development of an information base for water supply is presented. Secon, Phase 2 is addressed by presenting direction memoranda specifically focused towards water supply on Maui and illustrating the initial plan. Third, the formulation of plans emphasizing NED and EQ as well as mixed objectives is presented together with an assessment of associated impacts in Phase 3. Finally, Phase 4 is illustrated by addressing a number of key decisions and associated tradeoffs resulting in a recommended plan.

The format used is intended to assist the reader in cross referencing to previous parts of Section IV and in understanding the major outputs to the planning process. Material which demonstrates these outputs is presented in the right hand pages; references to Section IV and explanatory comments are given on the left hand pages. It is noted that detailed procedures used to generate the outputs are usually not included since these will vary from study to study depending on the experience of a particular study team and the requirements of a specific planning setting. However, in the case where the procedures used are somewhat generalizable, they are briefly discussed in the description of the process in previous parts of this section.

PHASE 1: DEVELOPMENT OF AN INFORMATION BASE FOR WATER SUPPLY ON MAUI

The purpose of Phase 1 is: (1) to start the planning effort for water supply on Maui by surfacing all problems relevant to Level B, (2) to select focuses for the study, and (3) to initiate the interaction between water supply and other functional areas. Key outputs in this phase are:

→ Information Display No. 1: List of All Problems

Information Display No. 2: Level B Focuses

Information Display No. 3: Content of Presentation for Public Involvement

Information Display No. 4: Final Selection of Focuses and Functional Interactions

INFORMATION DISPLAY NO. 1: Develops a comprehensive list of problems organized according to an appropriate set of problem categories related to the Maui water supply problem, and systematically identifying problems within each category (Section IV, pages 44 through 46).

1. During the initial stage of developing the list of problems, a precise choice of problem categories is not crucial as the list is subject to later modification. Its main purpose is to provide an organized framework for systematic collection of problems. In the case study the last category on Institutional Arrangements was added after cost sharing problems surfaced in the interviews.

(continued on page 88)

INFORMATION DISPLAY NO. 1.1: Water Supply Problem Categories

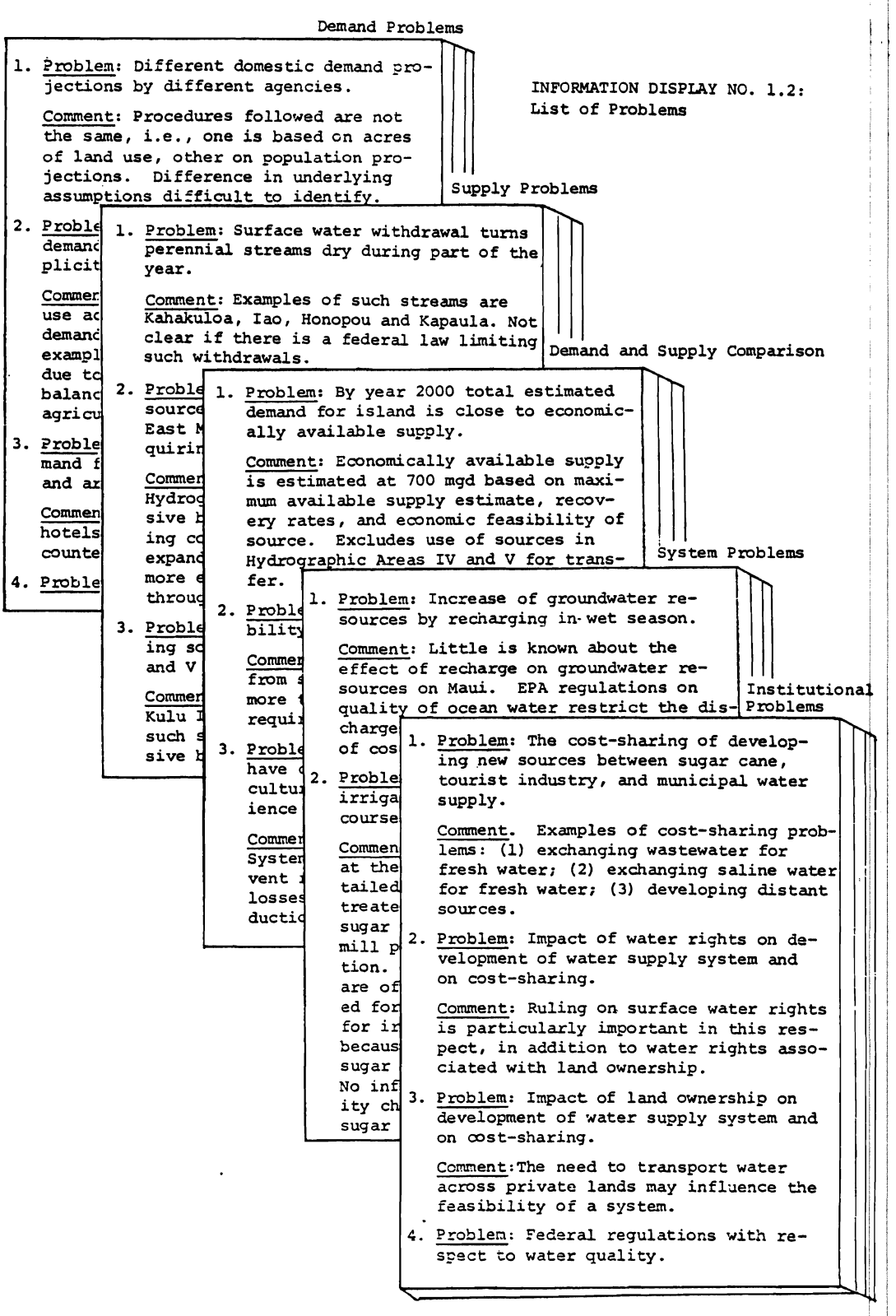
Categories	Main Characteristics Relevant to Level B
Demand Estimation	Uncertainties in demand due to uncertainties in the underlying factors of the demand such as land use and population projections.
Supply Measurement	Estimated cost and yield of supply sources.
Demand/Supply Comparison	Seasonal shape of demand and supply; variability of supply.
Water Supply System	Choice of sources, location, reuse and transportation.
Institutional Arrangements	Cost sharing private/public; laws and regulations.

2. A total of 31 problems were identified in the various categories. These resulted from: (1) the insight of the reviewers who surveyed reports including land use plans, newspaper articles, minutes of meetings, and detailed water supply plans; (2) conversations with experts concerning detailed operations of irrigation systems, planter's views on drip irrigation, cost sharing between plantations, resort and county development, and personal views on demand, supply and the environment; (3) checking through the list of EQ problems in the P&S. The withdrawal of all water from perennial streams during summer months is an example of the latter. The list of problems shown on the opposite page represents some typical problems of the entire display.

3. The list of problems was substantially modified after interviews with experts. For example: (1) transmission of water from southwestern part of East Maui was deleted from consideration; (2) increased energy needs for pumping in an expanding system was added; (3) implementation of drip irrigation was identified as less of a problem than uncertainties of its effects. Recommendation: After compiling an initial list of problems, talk to experts and concerned public at earliest possible time.

4. In the case study there was limited contact with the concerned public, and access to environmental experts was difficult. Recommendation: These sources should be consulted early in the study in order to improve upon an initially prepared list of problems.

5. It is noted that the range of problems considered for water supply extend well beyond a more conventional requirements approach where the emphasis is on designing a system to meet preestablished requirements. In fact, the uncertainty in requirements is a large part of the water supply problems on Maui.



INFORMATION DISPLAY NO. 1.2:
List of Problems

PHASE 1

Information Display No. 1

→ Information Display No. 2

Information Display No. 3

Information Display No. 4

INFORMATION DISPLAY NO. 2: Analyzes and screens Display No. 1 and selects potential Level B focuses (Section IV, pages 46 through 49).

1. It was found useful to choose one or more initial focuses in each problem category shown in Information Display No. 1, so as to provide a direction for information gathering and to limit this effort to information needed to back up selected focuses and priority ranking of problems. Choice of initial focus is largely based on judgment, is preliminary, and is subject to change. For example in the demand category an initial focus was:

> "study the uncertainty of water demand projections and need for increased accuracy."

To justify this focus information gathering was directed towards determining the influence of improved accuracy on choice of Level C studies and the importance of improved accuracy for different demand components. This investigation provided a stronger focus, i.e.,

> "develop more accurate water demand projections for the tourist industry and for agricultural and industrial needs in sugar production (Focus 1),

which subsequently was extended to include:

> "assess the impact of drip irrigation on agricultural land use and sugar production (Focus 2).

In the supply category an initial focus was:

> "obtain improved estimates of yields and costs of water supply sources on Maui".

To justify this focus information gathering was directed towards determining the need for this knowledge in improving the water supply plan and its importance for different sources. As a result of this investigation the initial focus was deleted and replaced by:

> "evaluate the impacts of (1) the Hanapepe decision with regard to surface water rights, and of (2) possible

(continued on page 92)

INFORMATION DISPLAY NO. 2.1: Potential Focuses for Water Supply Study on Maui

Problem Categories

Demand Estimation	1. Develop more accurate water demand projections for the tourist industry and for agricultural and industrial needs in sugar production.
	2. Assess the impact of drip irrigation on agricultural land use and sugar production.
Supply Measurement	3. Evaluate the impacts of (1) the Hanapepe decision with regard to surface water rights, and of (2) possible requirements for minimum streamflows, on the need for an additional investigation and subsequent development of supply sources.
Demand/Supply Comparison	4. Outline a program for developing information on the economic and physical feasibility of storing water between seasons by recharging of the groundwater.
Water Supply System	5. Develop a "best" plan for water supply to the extent possible given the uncertainty in basic parameters, and recommend specific studies to determine appropriate parameters for completing this plan.
Institutional Arrangements	6. Given a best plan, develop alternative cost-sharing rules that will be required to implement the plan; determine benefits to each party under alternative cost sharing strategies and compare with the situation where there is no agreement.

requirements for minimum streamflows, on the need for an additional investigation and subsequent development of supply sources (Focus 3).

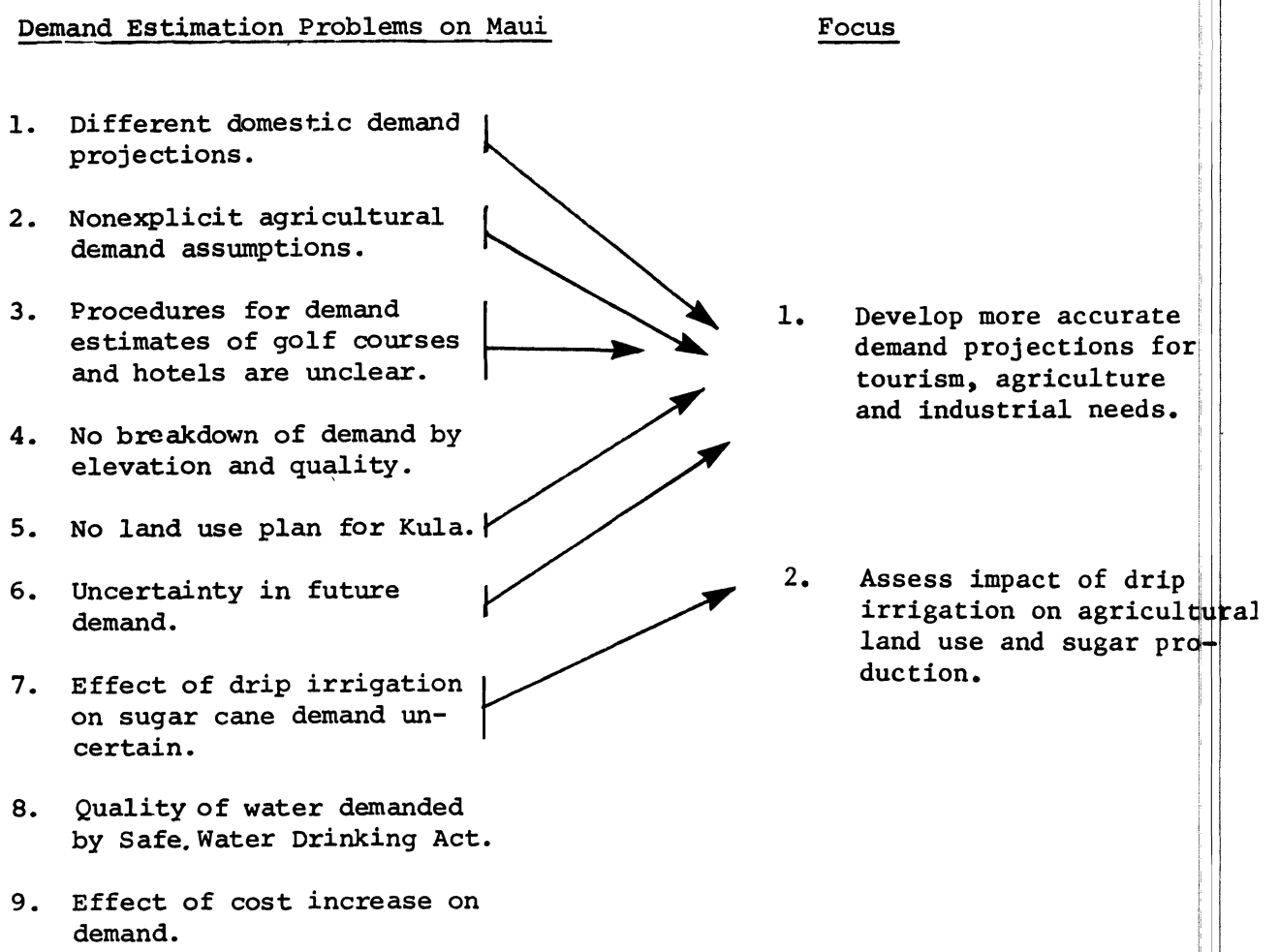
2. The choice of these initial focuses represents a judgmental and preliminary effort. It is noted that the effort to initially choose a focus is not wasted when a focus is subsequently modified. Rather it provides a useful starting point for an organized investigation.

3. Several problems of concern to Level B were combined into one focus. Problems which were considered to be outside the realm of Level B are described together with the rationale for their exclusion. This is illustrated for the demand estimating category in Information Display No. 2.2.

4. When the list of focuses was selected, each was analyzed in order to arrive at priorities among focuses, and to select those focuses to be further pursued in the plan formulation efforts. For those focuses not specifically addressed in plan formulation, recommendations were prepared in Phase IV.

(continued on page 96)

INFORMATION DISPLAY NO. 2.2: Focusing as Illustrated for Demand Estimation Category



(continued on page995)

INFORMATION DISPLAY NO. 2.2 (cont.): Problems Not Considered as Illustrated for Demand Estimation Category

Demand Problems

4. No breakdown of demand by elevation and quality.

   Reasons: The problem of separating demand projections by quality and elevation is relatively straightforward, and should be considered when making detailed projections for use in Level C planning. For Level B both elevation and quality should be considered in demand projections, but are not a serious enough problem to be used as a focus for the study.

8. Quality of water demanded by Safe Water Drinking Act.

   Reasons: The water quality standards present no serious regional Level B concern but should be reflected in the demand estimates made for Level B problems in Maui. It is not included here because it is not expected to change any projects recommended for follow-on Level C study.

9. Effect of cost increase on demand.

   Reasons: The effect of increase in cost of water on domestic and tourist industry demand is difficult to estimate and is not expected to be substantial. On the other hand, sugar cane growers on East Maui have decided that the cost of any new supply sources are too expensive and more efficient use of existing sources should be considered only. Because of the importance of studying the effects of drip irrigation and because of the complexity of investigating the sugar growers' response to increased water prices, this assumption is not further investigated in the Level B study. In the future however, studies undertaken by sugar companies in this respect should be reviewed and enlarged upon where needed.

5. The key elements of the analysis providing the rationale for including the focus in the plan formulation efforts are displayed for Drip Irrigation (Focus 2) and for Water Supply System (Focus 5).

6. Based on comments made in the workshops, the value of clearly stating all assumptions cannot be overestimated. These assumptions may very well be open to criticism, as happened in the case study. For example, in justifying the drip irrigation focus there was no universal agreement on the values for irrigation needs and sugar cane production under drip irrigation; in addition there were questions regarding land availability at sugar plantations and the intensity with which the land will be used. In the case of exchange between wastewater and freshwater, comments included the fact that wastewater needs to be delivered to alternative fields depending on the nutrient requirements, the local plan for wastewater was an infiltration well instead of outfall, and the value of the nutrient content of wastewater for sugar growth was not included in calculation. These comments did not alter the conclusions reached, however, and provided a starting point for cooperation in the next planning phase.

7. It should be noted that exploratory calculations for each focus are totally based on the ability to make explicit assumptions about uncertainties. This will in turn generate a basis for discussion.

(continued on page 98)

INFORMATION DISPLAY NO. 2.3: Rationale for Focus 2

Focus:

2. Assess the impact of drip irrigation on agricultural land use and sugar production.

Reason:

Uncertainties in land use and sugar production result from uncertainties in requirements for drip irrigation, in the recharge of groundwater and its recovery under furrow irrigation, and in the total amount of sugar production under drip irrigation.

Exploratory Calculation:

Exploratory calculations were made to investigate the impact of varying assumptions regarding drip irrigation on land use and sugar production on Maui.

Assumptions

- Total acreage of sugar cane fields is 30,000.
- Average annual yield per acre is 6 tons for furrow and 7.25 for drip irrigation.
- Application rate for furrow irrigation is 10,000 gallons/acre/day and for drip between 6,250 and 8,000 gallons/acre/day.
- Low and high values for groundwater recharge from furrow irrigation are assumed to be 25 percent and 40 percent, respectively, and 0 percent for drip irrigation.
- Low and high values for recovery of groundwater are assumed to be 20 percent and 60 percent, respectively.
- All water available for furrow will be used under drip irrigation.
- Three cases are considered with the following assumed parameter values.

		Furrow to Drip	
Parameters	Furrow	Case 1	Case 2
Annual Yield (tons/acre)	6	7.25	7.25
Applic. Rate (gals/acre/day)	10,000	6,250	8,000
Recharge Rate for Furrow	NA	25%	40%
Recovery Rate for Furrow	NA	20%	60%

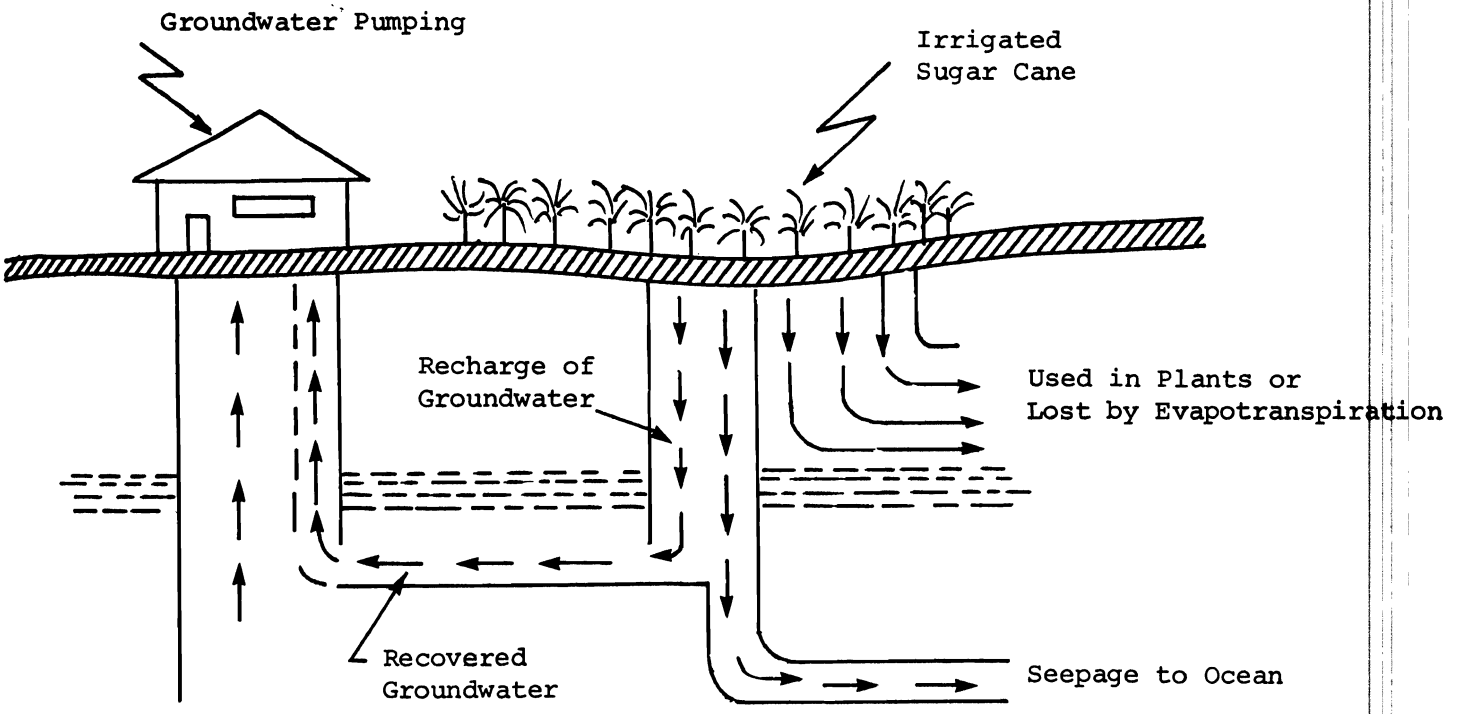
(continued on page 99)

8. The water balance provides a useful and simple tool to analyze interactions between the different aspects of water supply; i.e., the effect of change to drip irrigation on the available groundwater.

9. It is emphasized that the exploratory calculations are specifically directed to arrive at conclusions regarding the merits of further pursuing a focus. In some cases these exploratory calculations reinforced an initially perceived need for study while in other cases the initially perceived problem was considered of less importance and a modified focus resulted.

(continued on page 102)

INFORMATION DISPLAY NO 2.3 (cont.): Rationale for Focus 2



Results:

The following are results of the exploratory calculations:

Cases Investigated		Total Water Used Under Furrow in MGD	Decrease in Recovery of Recharge in MGD	Total Water Available in MGD	Acres Used for Sugar Cane	Annual Sugar Production in Tons
Furrow		300	0	300	30,000	180,000
Furrow to Drip	Case 1	300	15	285	45,600	330,600
	Case 2	300	72	228	28,500	206,625

Conclusion:

There is a substantial difference in land use and sugar production under Case 1 and Case 2; thus Focus 2 is justified and merits further study.

INFORMATION DISPLAY NO. 2.4: Rationale for Focus 5

Focus:

5. Develop a "best" plan for water supply to the extent possible given the uncertainty in basic parameters, and recommend specific studies to determine appropriate parameters for completing this plan.

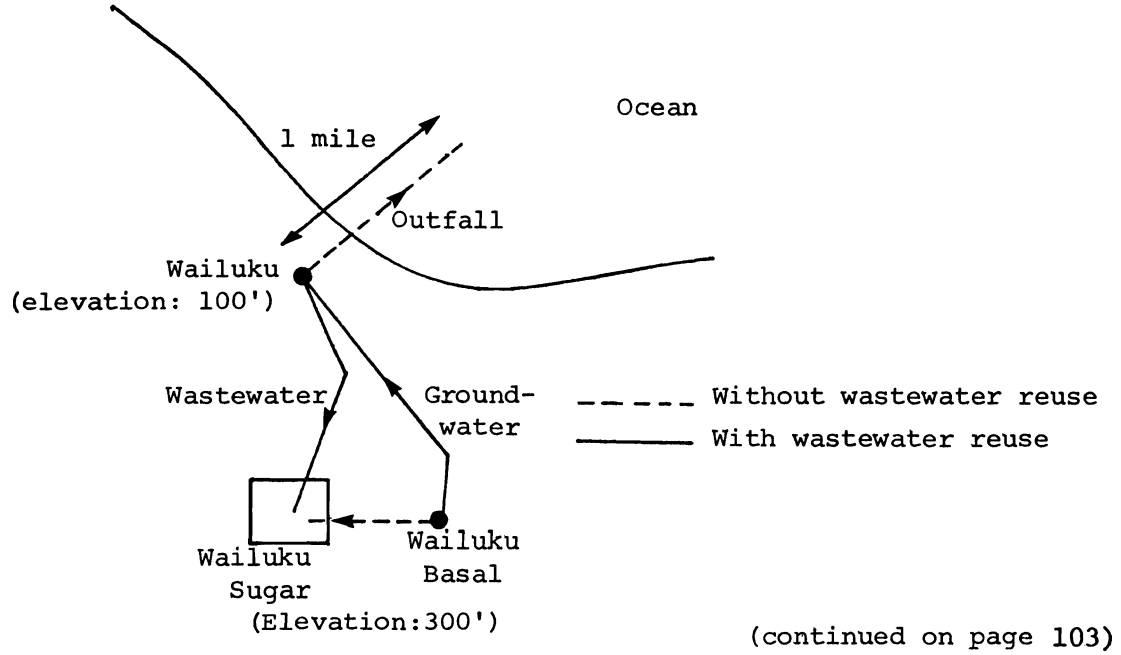
Reason:

The choice of components to be used in the Maui water supply system is not resolved in an overall master plan. Choices include:

- Exchange of wastewater in sugar field irrigation for freshwater in domestic use.
- Exchange of saline water in sugar field irrigation for freshwater in domestic use.
- Recharging of groundwater with excess water during winter months for use in summer.
- Transfer of water used to grow sugar cane to domestic use.
- Use of bagasse to satisfy energy requirements for pumping of water.

Exploratory Calculations:

Exploratory calculations were made for each of the above components to investigate the feasibility of considering it in development of a water supply plan for Maui. Results were used to recommend alternatives for further study. One choice is examined here: the exchange of wastewater for freshwater in sugar cane production.



(continued on page 103)

10. The conclusion stated on the opposite page exemplifies the use of exploratory calculations. The fact that the cost of the alternative considered is comparable to the cost of alternatives presently considered on the island provides important justification for addressing wastewater reuse in the plans.

Assumptions:

- Wastewater can be used interchangeably with freshwater to grow sugar cane.
- The available wastewater is 8 mgd which is equal to the projected domestic demand for 1990.
- The discount rate is 7 percent and the planning horizon 50 years.
- The length of outfall is 1 mile; distance from Wailuku treatment plant to Wailuku Sugar fields is 4 miles; distance from Wailuku basal to Wailuku is 4 miles.
- The outfall and transmission pipelines are 36" in diameter; friction losses amount to .5 ft. per 1,000 ft.
- The installed cost of transmission pipeline and outfall are $80/foot and $200/foot, respectively.
- The energy requirements are estimated using a formula based on the pump horsepower equation and $0.03/kwh.

Results:

The following are results of the exploratory calculations:

Ocean Outfall:

Cost of pipeline:	$1,056,000
Energy cost per year:	971
Annual cost:	971 + .07246 x 1,056,000 = $77,489

Wastewater/Freshwater Exchange:

Cost of pipeline	$3,379,200
Energy cost per year:	77,469
Annual cost:	77,469 + .07246 x 3,379,200 = $322,326

Cost of Freshwater:

(322,326 - 77,489) / 8,000 x 365 = $.084/1,000 gallons

Sensitivity Results:

Increasing the distance from 4 miles to 8 miles doubles the cost of water.

Increasing the energy cost from $0.03/kwh to $0.06/kwh increases the cost of water by 31 percent.

Conclusion:

The resulting cost of water is comparable to the cost of other alternative costs (which range between $0.06 and $0.30 cents per 1000 gallons); thus this alternative should be considered in the development of an overall plan.

PHASE 1.

Information Display No. 1

Information Display No. 2

→ Information Display No. 3

Information Display No. 4

INFORMATION DISPLAY NO. 3: Synthesizes the content of the presentation to the public regarding potential focuses and functional interfaces (Section IV, pages 49 through 51).

1. Information Display No. 3.1 provides an example of the type of information to be presented for Focus 5 at meetings with the public. Displays 3.2 and 3.3 provide supporting illustrations. The emphasis in selecting information is on a simple and straightforward explanation of rationale and importance of the potential focuses with minimal use of technical language.

2. It is noted that Information Display No. 3 differs from the actual displays that may be required for communication purposes such as slides, graphs, pictures, maps and oral explanations. Once the study team decides what type of information to convey, the need for an effective communication format becomes a subsequent consideration.

3. Information Display No. 3 is based on two efforts performed by the water supply team: (1) preparation of Information Display No. 2, and (2) identification of the interface with other functional areas from a water supply perspective. Displays 3.1, 3.2 and 3.3 are extracted from Information Display No. 2 while Display 3.4 relates to the second effort. Display 3.4 is used to initiate multifunctional planning and to present the public with the various interfaces perceived by the team.

INFORMATION DISPLAY NO. 3.1: Content of Water Supply Presentation for Meetings with the Public: Focus 5

1. Present summary of the focus for the water supply system problem on Maui.

   Focus 5: Develop a short-term plan for a water supply system on Maui, and organize a program of investigation that provides information for long-term plans.

2. Present the background information needed to facilitate understanding of the problem.

   - Explain general concerns in developing a water supply plan:
     - Low cost of water.
     - Efficient use of water.
     - Balance between uses such as for sugar cane, tourism, municipal services, and streamflow for fish and wildlife.
     - Protection of environmental quality.
     - Energy needs of expanded water supply system.
   - Describe possible supply sources available for extending the water supply system:
     - Additional groundwater development, mainly on West Maui.
     - Further depletion of streams on West Maui.
     - Pumping of water at Big Spring to ditch system.
     - Exchange of wastewater or saline water used for sugar cane irrigation with freshwater used for domestic services.
   - Describe uncertainties in key parameters which influence a decision on system design:
     - Effect of continued implementation of drip irrigation on irrigation requirements.
     - Feasibility and safety of using wastewater for sugar cane irrigation.
     - Yield of groundwater sources in West Maui.
     - Growth of tourism and sugar cane acreage.
     - Streamflow requirements in summer for perennial streams.

3. Explain the essence of the relationship between uncertainty in factors underlying the choice of system components and development of an overall water supply system plan. As an understanding of this relationship is crucial to understanding the focus for the study, give examples of uncertainty, such as:

   - A change in the efficiency of drip irrigation may influence the decision to include a transmission line from Ease Maui streams to Kihei in the plan (see Information Display No. 3.2).

(continued on page 107)

- Minimum streamflow requirements may have a substantial effect on system design (see Information Display No. 3.2).

- In addition to public health considerations, the efficiency of drip irrigation may have an effect on the inclusion of wastewater for sugar cane irrigation in the system plan (see Information Display No. 3.3).

4. Outline the conclusion reached after identifying uncertainties such as the above.

   - There are several options available for inclusion in a water supply system plan. However, the uncertainties underlying each option are substantial and before a choice can be made further study is needed to determine the feasibility of a particular option.

5. Restate the focus which is presently being considered for the water supply system problem on Maui.

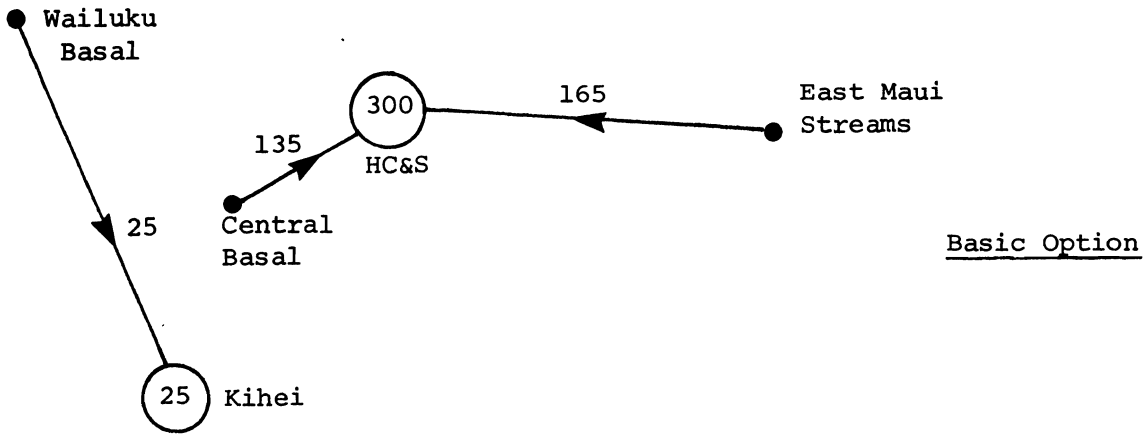
   - Reiterate the necessity of reducing and/or resolving key uncertainties in factors related to long-term decision making for a water supply system plan.

   - Restate the proposed focus for the water supply system problem:

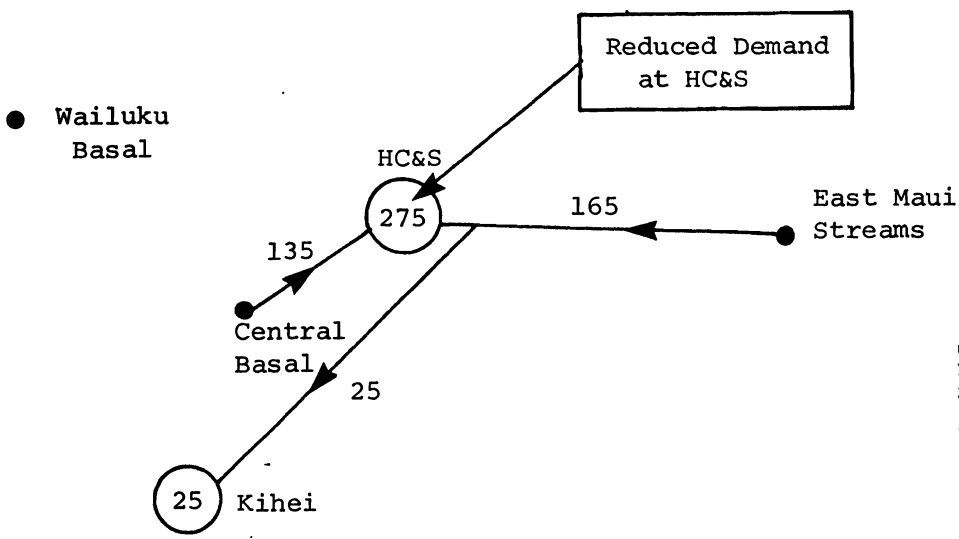
     - Develop short-term (10 year) plans for public consideration which include both separate NED and EQ plans and a mixed NED-EQ plan. This development effort will include consideration of uncertainties which have implications for future decision making such as the effect of using wastewater for sugar cane irrigation or of imposing minimum streamflow requirements for fish and wildlife. The plans developed will ultimately be used for selecting a short-term plan to be recommended for implementation.

     - Develop a program of investigation designed to reduce and/or resolve the uncertainties underlying a decision to choose a particular component in a long-term plan. (For the purpose of this focus, long-term is defined as after 1985.) Key uncertainties include: (1) public health considerations in using wastewater for sugar cane irrigation, and (2) demands on summer streamflows in perennial streams. Parameters related to drip irrigation such as application rate, infiltration and recovery rates, are covered in Focus 2.

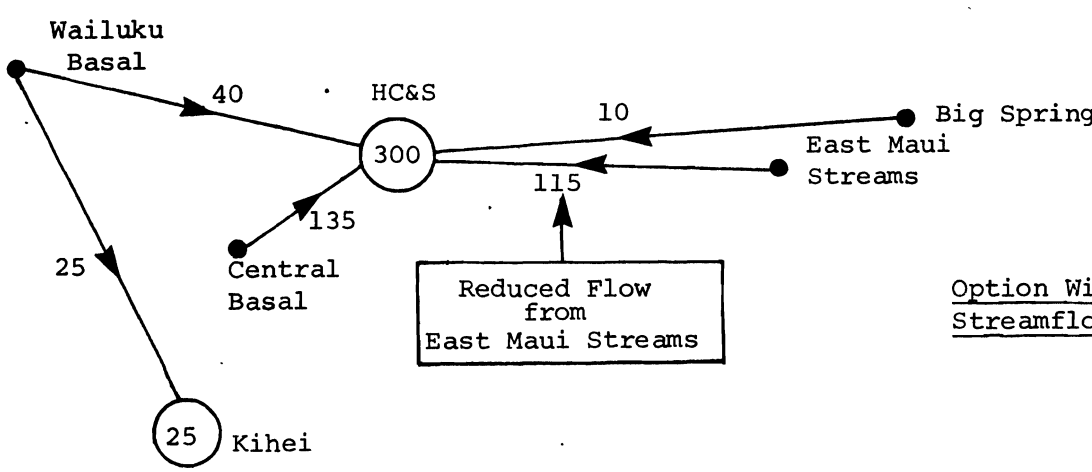
INFORMATION DISPLAY NO. 3.2: Influence of Irrigation Efficiency and Minimum Streamflows on System Plan



Basic Option



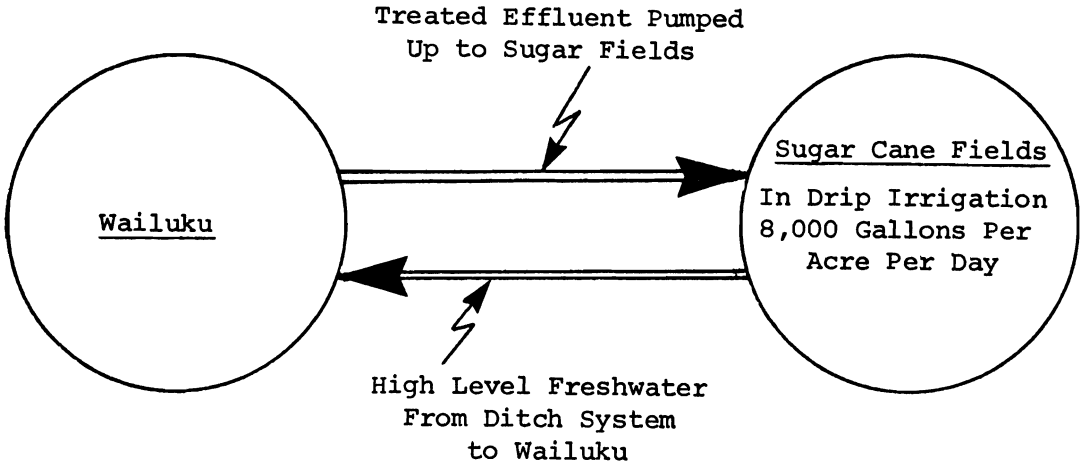
Option With Increased Efficiency from Drip Irrigation



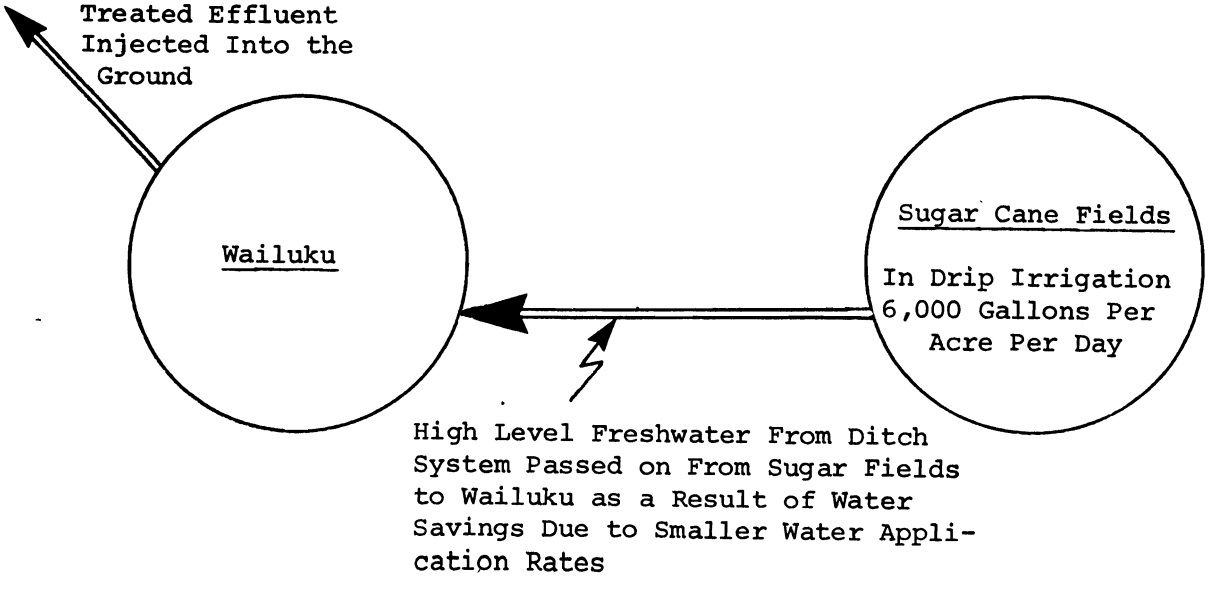
Option With Minimum Streamflow Requirements

INFORMATION DISPLAY NO. 3.3: Dependence of Wastewater Use on Drip Irrigation Efficiency

Option 1



Option 2



INFORMATION DISPLAY NO. 3.4: Interactions From A Single Function Perspective

Fish and Wildlife	Water Quality and Wastewater Mgmt.	Flood Control	Recreation	Sedimentation	Nav.
Minimum stream-flow requirements for fish and wild-life in perennial streams such as Kahahuloa, Iao, Honopou and Kapaula. Ecosystem changes due to diversions for sugar cane irrigation.	Pollution due to siltation in inshore waters caused by irri-gation practices. Use of waste-water at Wailuku, Lahaina and Kihei as a supply source for sugar cane irrigation. Quality of drink-ing water, i.e., violation of stan-dards in Makawao area.		Recreational use of streams in forest reserves at upper eleva-tions.	Consistency in assumptions re-garding irri-gation to cal-culate erosion losses.	

PHASE 1

Information Display No. 1

Information Display No. 2

Information Display No. 3

→ Information Display No. 4

INFORMATION DISPLAY NO. 4: (1) reflects priorities and possible modification of the focuses selected for further plan formulation based on feedback received from the public when all Level B focuses were presented to them, and (2) formalizes the interactions to be dealt with in the study as agreed upon by the various teams given the selected focuses (Section IV, pages 51 through 53).

1. For the purposes of the case study, the only interactions considered are between water supply and water quality and wastewater, and between water supply and fish and wildlife. Thus interactions of water supply with recreation and sedimentation are not further analyzed.

2. Potential pollution due to siltation in inshore water from irrigation practices was considered to be an important interface from a water supply perspective (see Display 3.4). However, after consulting with study teams engaged in water quality planning efforts it was concluded that this interface could be eliminated because of discharge limitations. It was further noted that wastewater as a potential supply source should be included and an assessment of quality of wastewater for sugar cane irrigation should be added. The latter was judged to be important because of the high content of nutrients in wastewater which makes it noninterchangeable with freshwater. Finally, while quality of drinking water due to violation of standards in the Makawao area was initially identified as a possible interface (see Display 3.4), it was later eliminated because planning efforts are already underway to address this issue.

3. In the interface with fish and wildlife, ecosystem changes due to diversions for sugar cane irrigation (see Display 3.4) was eliminated from further consideration because extensive analysis, undertaken by the Fish and Wildlife team, would be necessary to identify ecosystem changes before analysis of this interface could be fruitful.

INFORMATION DISPLAY NO. 4: Final Selection of
Focuses and Functional Interactions

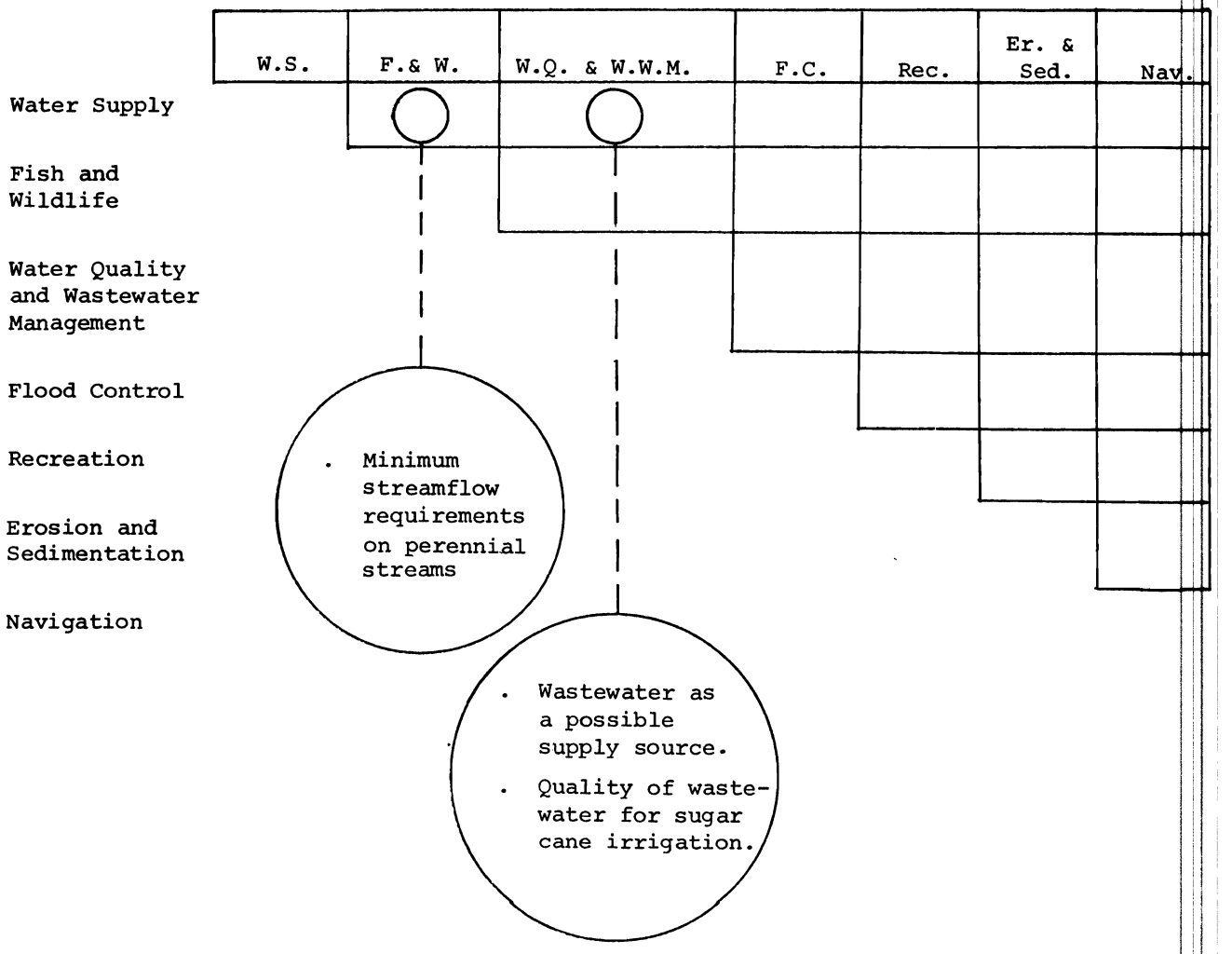
Focuses Selected

The following focuses are selected based on the assignment of priorities to the potential Level B focuses and given the budget and time constraints of the study:

Focus 2: Assess impact of drip irrigation on agricultural land use and sugar production.

Focus 5: Develop best plan for water supply to extent possible given the uncertainty in basic parameters, and recommend specific studies to determine appropriate parameters for completing best plan.

Functional Interactions Selected



PHASE 2: FIRST ITERATION TOWARDS FORMULATION OF PLANS AND/OR STRATEGIES

The purpose of Phase 2 is to further specify the direction of the water supply plan formulation efforts on Maui and to formulate an Initial Water Supply Plan. Key outputs in this phase are:

→ Direction Memoranda

Initial Plan

DIRECTION MEMORANDA: Serve the dual purpose of (1) presenting the study team's view of the work plan regarding each selected focus for the study manager's review, and modification or approval of the work proposed, and (2) providing the study manager with a basis for formalizing multifunction coordination between the water supply study team and efforts in other functional areas. For the first purpose, it is necessary to provide the study manager with specific rationale for the effort proposed in order to facilitate decision making. Two such Direction Memoranda are illustrated: Water Supply System (Focus 5) and Drip Irrigation (Focus 2). A third Direction Memorandum is presented to illustrate the second purpose. It addresses the interface between water supply and water quality and wastewater management, and between water supply and fish and wildlife (Section IV, pages 55 through 68).

1. Direction Memoranda prepared by the study team address: (1) special considerations which provide the basis for the work plan proposed; (2) anticipated study output; (3) key elements delineating the water supply work plan which in turn will provide a benchmark for measuring the team's effort.

2. All Direction Memoranda prepared by the teams for the different focuses selected within each functional area are reviewed by the study manager in order to decide on an overall work plan for the Level B study. This work plan, to be presented in the First Cut Report, details the study effort for each focus to be addressed in the Level B study. Thus based on the review, the proposed efforts may be accepted, reduced in scope, or replaced by others more in line with available budget and time. In addition, after reviewing the Direction Memoranda from the various teams, the study manager organizes the multifunctional aspects of the study by delegating the responsibility for certain multifunctional efforts to study teams either on a permanent or preliminary basis. The results are summarized in a Direction Memorandum by the study manager.

(continued on page 118)

DIRECTION MEMORANDUM: Water Supply Systems

To: Study Manager

From: Water Supply Team

Date: May 15, 1975

Subject: Water Supply System (Focus No. 5)

---

1. Purpose

The purpose of this memorandum is to delineate the anticipated output and associated effort by the team in addressing the Water Supply System Focus No. 5 presented to the public in Phase 1:

> "Develop short-term (10 year) plans for public consideration which include both separate NED and EQ plans and a mixed NED-EQ plan. This development effort will include consideration of uncertainties which have implications for future decision making such as the effect of using wastewater for sugar cane irrigation or of imposing minimum streamflow requirements for fish and wildlife. The plans developed will be used for ultimately selecting a short-term plan to be recommended for implementation."

> "Develop a program of investigation designed to reduce and/or resolve the uncertainties underlying a decision to choose a particular component in a long-term plan. (For the purpose of this focus, long-term is defined as after 1985.) Key uncertainties include: (1) public health considerations in using wastewater for sugar cane irrigation, and (2) demands on summer streamflows in perennial streams. Parameters related to drip irrigation such as application rate, infiltration and recovery rates are covered in Focus 2."

This memo describes the scope of the study team efforts, special consideration, constraints, budget, and time frame. It represents the study team's approach to the selected focus and will serve as a basis for deciding on the planning steps ahead.

2. Considerations

Key considerations of the study team in defining the Level B effort for Focus No. 5 are:

- Emphasis will be placed on an aggregate plan which identifies both sources of supply and demand centers served by these sources. This emphasis is chosen because such a plan is nonexistant and also because the budget does not allow for development of a more detailed plan.
- Because of uncertainties in the problem parameters, decisions are only expected for the short-term (i.e, 1975-1985). This consideration is based on the fact that without additional information on major parameters such as the effects of drip irrigation on irrigation requirements, decisions made for the period beyond 1985 may be irrelevant.
- Long-term plans for the year 2000, assuming different parameter values, will be used to identify short-term decisions which are required to insure the future viability of the corresponding long-term plan. Short-term decisions associated with different long-term plans will be compared;

(continued on page 119)

3. The Direction Memorandum should be viewed as a preliminary and changing document. It can be extremely useful in setting the stage for work in the next planning phase.

4. The first version of a Direction Memorandum may be modified at various points in time based on suggestions either by the study team or the study manager. The study team may suggest modifications because of additionaliinformation uncovered new problems encountered, data collection problems arising, or inability to complete tasks within budget and time constraints set by the study manager. Modification suggested by the study manager may be based on considerations such as overall budget or manpower available for the Level B study interactions with other study teams, or importance of problem resolution with respect to the overall Level B effort.

5. A time constraint on the preparation of Direction Memoranda may be a useful device for forcing a decision with respect to how the study team plans to proceed.

6. Developing long-term plans for the purpose of identifying short-term decision is a useful device for a Level B study because of its broad scope. Thus, planning is not directed towards selecting the best long-term plan; rather, emphasis is placed on analyzing and comparing long-term plans in order to select the best short-term decisions. These decisions constitute the recommended plan.

7. Selecting the appropriate level of detail to be used in plan formulation is an important consideration. For example, in the study it will be necessary to aggregate several smaller deman centers to form a few major demand centers. Similarly, several supply sources will have to be aggregated. As a result of the aggregation of deman centers and supply sources the study is not carried on to the level of detail usually found in system design studies. Thus, actual sizing and layout of pipes is considered beyond the scope of the Level B effort.

(continued on page 122)

if all plans for the year 2000 require the same short-term decision there will be no need to make tradeoffs. However, if some short-term decisions are identified which lead to different long-term plans, the advantages and disadvantages of such decisions will be compared in the Phase 4 trade-off analysis. In addition, year 2000 plans will be compared in order to estimate the relative importance of obtaining better estimates for the future values of certain parameters.

3. Anticipated Outputs

As an intermediate output the study team will first produce an Initial 2000 Year Plan representing local water supply planning efforts, and a set of First Cut 2000 Year Plans representing the study team's ideas as to where and how in Maui's water supply system improvements can be achieved both from an NED and an EQ perspective. Further analysis of these plans will most likely lead to a set of modified 2000-year alternatives. Based on investigation of the plans generated, options for short-term plans will emerge which will be used in trade-off analysis to determine a recommended short-term water supply plan for Maui - a final output of the study. In addition, information needed to decide on a long-term plan (i.e., for the year 2000) will be identified and recommendations for further investigation will be made. This will allow a timely selection of a long-term alternative prior to 1985.

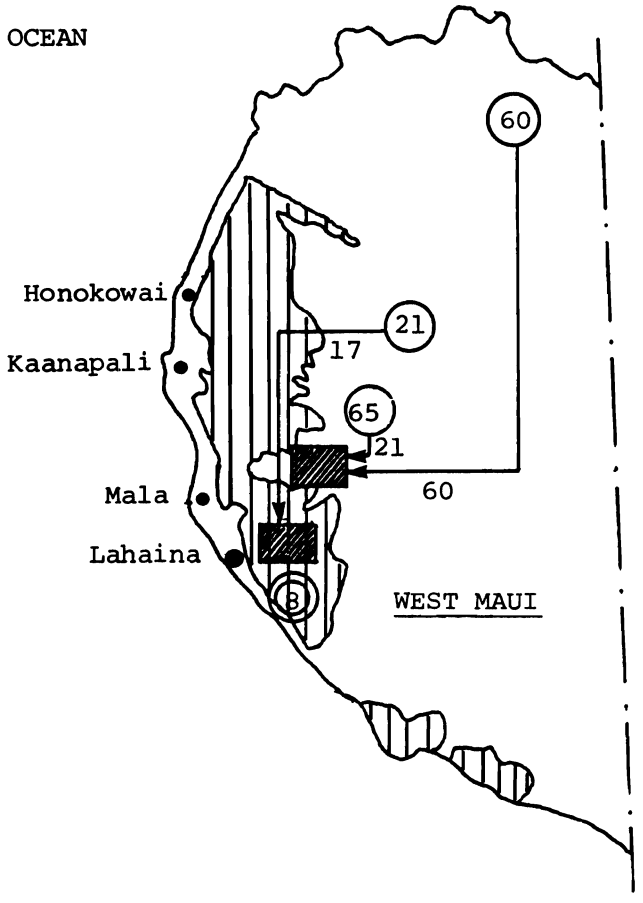
4. Level of Aggregation

The level of aggregation proposed for this study is presented below for West Maui and illustrated on the next page. All domestic demand, including demand for resort developments such as at Kanaapali, is indicated by a single demand center at Lahaina; demand for irrigation by the Pioneer Mill's sugar cane fields is also represented by one demand center. Similarly, supply sources are presented by single centers for high level groundwater, basal groundwater, and streamflows. A plan provides the allocation of these aggregate supplies to the aggregate demands as illustrated below. The same level of aggregation is proposed for Central and East Maui.

Demand/Supply Information: West Maui

	Demand Centers		
Supply Sources	Domestic Demand to "Lahaina"	Irrigation Demand to "Pioneer Mill"	Available Supply
Lahaina			
High Level Groundwater	17		21
Basal Groundwater		21	65
Streamflows		60	60
Wastewater			8
Demand	17	81	

(continued on page 123)



LEGEND

All numbers refer to water in mgd

(60)	Utilized Supply Center with capacity 60
(8)	Unutilized Supply Center with capacity 8
▨	Demand Center
——	Transmission Line
10	Transmitted Water in MGD
▥	Sugar Cane Fields

(continued on page 123

8. Seven key elements have been identified for the work related to this focus. The number and content of the key elements depends on the subject matter under consideration. It is important, however, to make as complete a list as possible at this time since it represents a first "best" estimate of the starting point and will be used by the study manager as his basic information for decisions on the scope of the overall Level B study.

5. Key Elements for Plan Formulation and Evaluation

Key elements of the proposed effort, as currently envisioned by the study team, are briefly described in the following:

(a)	Characterization of demand	. Water Demand Centers - Domestic (4 centers) - Sugar Cane (3) . Water Supply Sources - Basal Groundwater (3) - High Level Groundwater (2) - Wastewater (3) - Streamflow (4)
(b)	Parameters for which plan sensitivities will be investigated	. Range of uncertainty in drip irrigation effects and requirements. . Growth of sugar cane production and tourist industry. . Alternative minimum streamflow restrictions.
(c)	Emphasis in NED/EQ plans	. NED on decreased cost of water supply system and/or increase in sugar production and in tourism. . EQ on satisfying streamflow levels on such streams as Kahakuloa, Iao, Honopou and Kapaula streams and on decreased use of energy resources through high level source development instead of pumping groundwater.
(d)	Constraints	. Existing system for water supply. (The decision on how to supply Kihei is left open for investigation even though plans are in advanced stage of development.)
(e)	Data availability	. This will be reviewed in the near future as soon as data needs are better defined.
(f)	Time schedule	. Five man months with a substantial part in the initial phase of the study. Detailed tasks and schedule will be provided later.
(g)	Budget	. $20,000 of the water supply budget is needed for this investigation. $40,000 remains for other water supply efforts.

DIRECTION MEMORANDUM: Drip Irrigation

To: Study Manager

From: Water Supply Team

Date: May 15, 1975

Subject: Drip Irrigation Investigation (Focus No. 2)

---

1. Purpose

The purpose of this memorandum is to delineate the anticipated output and associated effort by the team in addressing the Water Supply System Focus No. 5 presented to the public in Phase 1:

> "Determine the feasibility and desirability of preparing an investigation program to be implemented outside the Level B study for assessing the impact of drip irrigation on agricultural land use and sugar production."

This memo describes the scope of the study team efforts, special consideration, constraints, budget, and time frame. It represents the study team's approach to the selected focus and will serve as a basis for deciding on the planning steps ahead.

2. Considerations

The key considerations of the study team in selecting the Level B effort proposed are:

- Physical investigations to reduce the uncertainty in parameters relevant to drip irrigation are not feasible within Level B budget and time frame.
- Organization of investigation is important in order to: (1) obtain improved estimates of parameters that can provide for a better planning capability, and (2) insure that these improved estimates are available when decisions are needed for planning the water supply system.
- There is a need to communicate consequences of uncertainty i drip irrigation to land use planners.

3. Anticipated Output

Level B output will include the following:

Information Needs	Time Schedule	Agency	Budget	Use In Decision Process
Groundwater recharge and recovery rates with furrow irrigation Requirements with drip irrigation Effects of change in recharge on quality of groundwater and ocean	For these three information needs the Level B Study will recommend a time schedule, agency participation, budget and uses of information in the decision process.			

(continued on page 130)

(b) Indication of dependence of land use and growth on performance of drip irrigation.

- Provide land use planners with range of impact on land use and growth given:
  - Alternative land use and growth objectives
  - Present uncertainty in effects of drip irrigation.
- Identify information needed on public preferences to assure best plan as well as timing for this information.

4. Key Elements for Drip Irrigation Investigation

Key elements of developing a program for the investigation of drip irrigation, as currently envisioned by the study team, are described in the following:

(a) Information Needs	Identify information needs, prepare an outline of the research efforts required, and organize a program of investigation for each information need identified.
(b) Agencies	Interview USGS, SCS, DOWALD and sugar companies and assess their capabilities to perform necessary research tasks.
(c) Time Schedule	One man-month spread over time, where timing of tasks depends on input from water supply plan effort on what information is required at what point in time. One-half time spent on interviewing agencies to determine potential research efforts. Last half of time will be used to develop an investigative program and provide input to land use planner.
(d) Budget	$4,000 is considered sufficient for this focus given the available expertise within the team and the inputs expected from the efforts on the water supply plan.

DIRECTION MEMORANDUM (MULTIFUNCTION COORDINATION): Comments

1. The study manager provides a strategy whereby it is possible to incorporate multifunction planning in a Level B study. This strategy has three key elements.

   a. In dealing with an interface such as the use of wastewater for irrigation on Maui, each study team involved is required to further specify their views as to what this interface entails. They should specify where the interface may occur (e.g., where on the island wastewater reuse for irrigation is viable), how the interface can be realized (e.g., what connections will be necessary), and what recommendation can be presented to the public (e.g., supply x mgd of treated effluent to demand center A).

   b. The study manager makes a decision to assign multifunctional aspects of the recommendation (e.g., the benefits and costs accruing to both functions).

   c. The study manager makes a decision on when in the sequence of Level B plan formulation the interface issues should be addressed.

DIRECTION MEMORANDUM: Multifunction Coordination

To: Water Supply, Water Quality and Wastewater Management, and Fish and Wildlife Study Teams

From: Study Manager

Date: May 22, 1975

Subject: Multifunction Coordination

---

1. Purpose

The purpose of this memo is to propose a strategy whereby the affected study teams can effectively deal with the interfaces between water supply and water quality and wastewater management, and between water supply and fish and wildlife in the Level B study.

2. Background

Information Display No. 4, Phase 1, identifies the following interfaces for consideration in the Level B planning efforts:

- WS/WQ & WWM: Wastewater is to be included in the short-term water supply recommendations for Maui as a possible source for meeting demand.

  In investigating wastewater as a possible source for sugar cane irrigation, it is necessary to consider jointly wastewater as a source for meeting irrigation demands as well as a product to be discharged in wastewater management.

- WS/F&W: In developing Level B water supply recommendations, streams such as Kahahuloa, Iao, Honopou and Kapaula streams will be considered as possible supply sources.

  In investigating these as possible sources it is necessary to consider jointly the minimum flow requirements for fish and wildlife (i.e., investigate the streams from the perspective that they are demand centers for fish and wildlife) and their capacity for water supply.

3. Strategy

The objectives of the strategy are to arrive at an efficient division of responsibility for Level B plan formulation efforts among the teams, and to ensure an effective treatment of the interfaces described above.

a. Initial Plan Formulation Efforts

Initial plans should include an indication of how a particular interface has been addressed by local interests. For example, the use of wastewater from Wailuku for irrigation at HC&S has apparently been considered as a viable option; thus this option should be reflected in both the WS and WQ & WWM team's initial plan.

(continued on page 131)

b. First Cut Plan Formulation Efforts

While the First Cut Plan is being developed, each team should also attempt to further specify where the interface may occur, how the interface may be realized, and what recommendation may be made in the Level B study regarding the interface. For example, both the WS and the WQ & WWM teams should consider issues such as possible ways to use wastewater as a supply source, possible demand centers on Maui for wastewater, and the feasibility of connecting a particular supply source to a demand center. In addition, they should identify problems that, from their frame of reference, could arise when it becomes necessary to formulate an alternative to their First Cut Plans which emphasizes wastewater reuse. These efforts will provide a basis for delegating the responsibility to develop a recommendation regarding wastewater use to either the WS or the WQ & WWM team.

c. Allocation of Responsibility for Multifunction Planning

After reviewing each team's First Cut Plan and views on issues associated with the interface, a decision will be made as to which team will be responsible for analyzing an interface in detail and for developing the associated recommendation for the Level B study. For example, while no firm decision has been made, it appears that the F&W team is well equipped to handle the interface between F&W and WS. If the F&W team is in fact made responsible for this analysis, they will be required to define and recommend minimum streamflow requirements for Maui based on an examination of advantages and disadvantages of these requirements from both a F&W and WS perspective. In this situation, the F&W team will need to maintain close contact with the WS team, soliciting their input on water supply plans, demand centers and supply sources on the Island, costs and other issues pertaining to the interface. Similarly, if the WQ & WWM team is made responsible for recommending how and where wastewater is to be reused on Maui, they will need to understand, weigh, and incorporate the concerns of the WS team in that recommendation.

PHASE 2

Direction Memoranda

→ Initial Plan

INITIAL PLAN: Provides a composite representation of local water supply planning efforts and serves as the basis for further plan formulation emphasizing NED and EQ (Section IV, pages 55 through 61).

1. The initial Year-2000 Plan presented for water supply on Maui provides a means for comparing the plans to be formulated in the study (see Direction Memorandum on Water Supply System). It is based on extensive review of various reports (i.e., water planning reports prepared by the State of Hawaii, County of Maui, sugar companies, etc.) and on interviews with local planners. The initial plan is generally not unique in view of normal differences of opinion and alternative options under consideration.

2. Aggregate representation of local plans is not always simple because of the great detail present in these plans. However, it is important in Level B planning to capture the most essential parts of a plan in order to present a composite picture of the most important decisions and associated tradeoffs to be addressed in Level B plan formulation. Otherwise both the decision makers including the public and the planner get lost in the complexities of too much detail.

3. The initial plan is presented in terms of the assumptions on water demands, supplies and the basis for choosing particular connections between supplies and demands. With respect to the assumption on demand and supply it is noted that in a workshop with local water supply planners it was emphasized that the seasonal shape of demand and supply are essential for proper planning of water supply on Maui. Using monthly average values would increase the complexity of the case study substantially, without contributing to the objectives of the case studies. For this reason average annual values are used. However, in an actual study average summer and winter values should be used.

(continued on page 138).

INITIAL PLAN: Demand Assumptions

	Present	2000
Lahaina Domestic[1)]	3	17
Pioneer Mill[2)]	102	81
Wailuku Domestic[1)]	4	10
Wailuku Sugar[2)]	50	45
HC&S[2)]	305	303
Kula[3)]	1.6	6
Kihei[1)]	2	18

---

1) Based on demands for the year 2000 in Maui Master Plan Report; Lahaina and Kihei include demands for resort areas.

2) Irrigation requirements are derived from the following application rates and acreages for the year 2000. These are based on the assumptions that for the year 2000 the acreage at Pioneer Mill and Wailuku Sugar are the same as at present and that acreage at HC&S will increase by 3,600 acres. It is noted that the increase in acreage at HC&S is due to the savings in water afforded by drip irrigation thereby allowing more acreage to be placed in production while still causing a slight decrease in water use.

Irrigation Method	Application in Gallons/Acre/Day	Pioneer Mill Acres	Wailuku Sugar Acres	HC&S Acres
Furrow	10,000	4,500	2,500	13,000
Drip	8,000	4,500	2,500	21,600

3) Based on 5 percent growth trend used in report "An Assessment of the Kula Water Situation" (1973) by Division of Water and Land Development; includes irrigation requirements for truck farmers; there is substantial uncertainty because of absence of land use plan for Kula area.

INITIAL PLAN (cont.): Supply Assumptions

Water Supply Centers	Present Yield (in mgd)	Potential Yield (in mgd)
Lahaina High Level Groundwater[1]		21
Lahaina Basal Groundwater[1]	46	65
Lahaina Streamflows[2]	60	60
Lahaina Wastewater[3]		8
Wailuku High Level Groundwater[4]		10
Wailuku Basal Groundwater[5]	5	29
Wailuku Streamflows[2]	73	73
Wailuku Wastewater[3]		5
Central Basal Groundwater[6]	117	108
Kihei Wastewater[3]		9
East Maui Streamflows[2]	165	165
Big Spring[7]		10

---

1) These increases are from DOWALD reports, and represent new high level groundwater and new basal groundwater needed to satisfy increased demand. It does not represent what actually can be supplied because of basic uncertainties in the amount available. All present groundwater is included under basal.

2) No further increase in streamflow withdrawals is desirable.

3) Wastewater is assumed equal to 50% of domestic use.

4) Knowledge about available supplies is small and estimate of 10 mgd is therefore speculative.

5) Increase is based on present development of 10 mgd reduced by 1 mgd to reflect the effect of 2,500 acres in drip irrigation, and proposed 20 mgd development in West Maui mountains; all characterized as basal because of substantial pumping involved.

6) Reduction is based on estimated reduction in groundwater supply of 500 gallons per day for every acre converted to drip irrigation, i.e., for HC&S 18,000 x 500 = 9 mgd.

7) Based on measured flow at spring.

(continued on page 137)

INITIAL PLAN (cont.): Basis for Choices in Year 2000 Plan

The initial plan was developed to reflect the various local plans for water supply. A plan to use wastewater from Wailuku for sugar cane irrigation is currently under discussion; it was also included. Considerations in choosing a particular supply source for a demand center (as presented on page 139 are as follows:

- Lahaina Domestic: in supplying the 17 mgd demand, high level groundwater is preferred over basal groundwater because its quality is better and it does not have the higher energy needs associated with basal.

- Pioneer Mill: streamflow is chosen first to supply 60 mgd of the total 81 mgd demand, with the additional 21 mgd supplied by basal groundwater. Streamflow is preferred because of pumping requirements and, in some cases, salinity of the basal water.

- Wailuku Domestic: basal groundwater is used, as is the current practice, to supply the 10 mgd demand. High groundwater is not chosen because the yield is uncertain and the costs are expected to be high.

- Wailuku Sugar: streamflow is chosen to meet the 45 mgd demand. Groundwater is not used because of the associated pumping needs.

- HC&S: several sources are chosen to meet the 303 mgd demand. In order of preference these include: (1) East Maui streamflow is first in the order of preference because there is no need for pumping; after deducting the 6 mgd required to supply Kula this amounts to 159 mgd; (2) the next source used is Wailuku streamflows for the same reason as above, however based on an agreement with Wailuku sugar, the amount is limited to 23 mgd; (3) central basal groundwater is then chosen to supply 108 mgd because it has the lowest associated pumping cost; (4) wastewater from Wailuku is used next to supply 5 mgd provided that a decision is reached regarding its use for sugar cane irrigation; and (5) the remaining 8 mgd is supplied by Big Spring; this source is anticipated as the next in line for development.

- Kula: East Maui streamflows are chosen to supply 6 mgd based on an assumption that the present agreement between the County and the East Maui Irrigation District (HC&S) will be expanded.

- Kihei: Wailuku basal groundwater is used to supply the 18 mgd demand based on a local plan.

(continued on page 139)

4. A simple format for presentation of plans was found to be useful in analyzing and displaying alternative plans. Since the initial plan forms the basis for subsequent plan development, its format is most important. Therefore it is recommended that the plan presentation format and initial plan be developed simultaneously.

5. In some cases the planning efforts can be simplified by separating it into two or more smaller elements. In Maui, for example, it was possible to plan independently for Lahaina and for Central Maui as indicated in the initial plan format. The separation was possible because source lccations and distances make interaction economically infeasible. It is recommended that this choice of separating the effort be investigated immediately following initial plan development.

6. The schematic presentation of the initial plan is presented in the foldout on page 211.

INITIAL PLAN (cont.): Initial Plan for Year 2000

Supply \ Demand	Lahaina Domestic	Pioneer Mill	W. Maui Stream-Flows	Wailuku Domestic	Wailuku Sugar	HC&S	Kula	Kihei	Wailuku and E. Maui Streamflows	AVAILABLE SUPPLY
LAHAINA										
High Level Groudwater	17									21
Basal Groundwater		21								65
Streamflows		60								60
Wastewater										8
WAILUKU										
High Level Groundwater										10
Basal Groundwater				10				18		29
Streamflows					45	23			5	73
Wastewater						5				5
Central Basal Groundwater						108				108
Kihei Wastewater										9
East Maui						159	6			165
Big Spring						8				10
DEMAND	17	81		10	45	303	6	18	5	

PHASE 3: ANALYSIS AND MODIFICATION OF PLANS AND/OR STRATEGIES

The purpose of Phase 3 as interpreted for the Maui water supply study is: (1) to develop alternatives to the initial long-term water supply plan for the year 2000 developed in Phase 2; (2) to select from these a set of alternatives that covers the range of water supply plans for Maui, and which subsequently will be compared; (3) to extract from the selected alternative long-term plans the associated short-term decisions to be analyzed in Phase IV for their inclusion in a short-term recommended water supply plan on Maui.

The key outputs that were generated by the water supply team during this phase are: (see opposite page)

FIRST CUT NED PLAN: Emphasis on contributions towards National Economic Development.

FIRST CUT EQ PLAN NO. 1: Emphasis on contributions towards Environmental Quality.

FIRST CUT EQ PLAN NO. 2: Emphasis on contributions towards Environmental Quality.

MODIFICATIONS TO FIRST CUT PLANS:

NED a: Emphasis on reduced irrigation demand for water.

NED b: Emphasis on increased irrigation demand for water.

NED c: Emphasis on the interface between water supply, and water quality and wastewater management (responsibility water supply team).

EQ a: Emphasis on improving the EQ aspects associated with the First Cut EQ plan.

EQ b: Emphasis on the interface with fish and wildlife (responsibility fish and wildlife team).

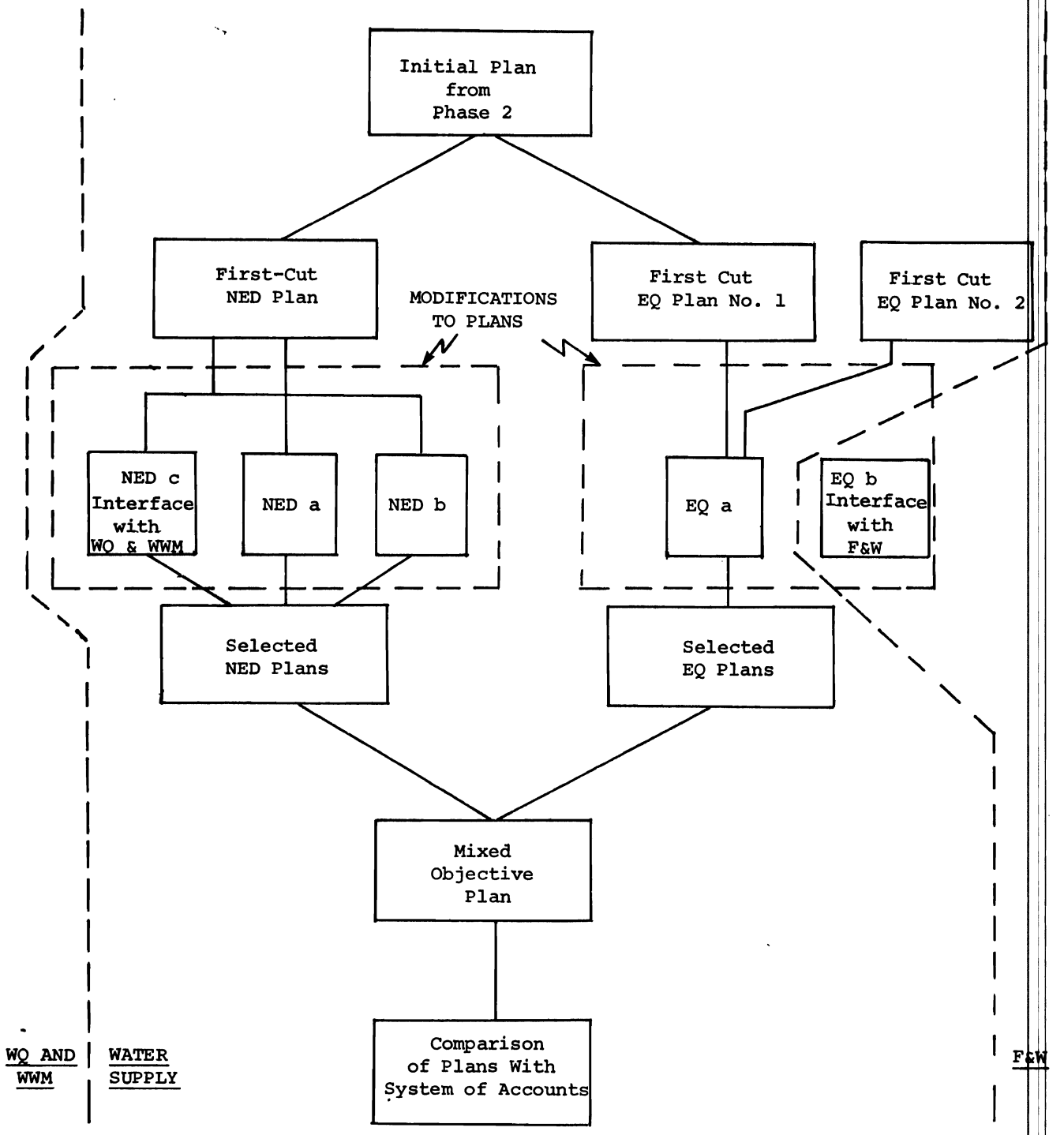
SELECTED NED PLANS: Based on comparison of the First Cut NED plan, NED a and NED b.

SELECTED EQ PLAN: Based on comparison of the First Cut EQ plans, and EQ a.

MIXED OBJECTIVE PLAN: Emphasis on capturing the full range of plan impacts by selecting a plan in between the selected NED and EQ plans.

COMPARISON OF PLANS: Emphasis is on comparing the selected plans using the system of accounts from the P&S.

PHASE 3: Outputs for Maui



PHASE 3

→ First Cut NED	NED a	Selected NED	Comparison of Plans
First Cut EQ No. 1	NED b	Selected EQ	
First Cut EQ No. 2	NED c	Mixed Obj. Plan	
	EQ a		
	EQ b		

FIRST CUT NED PLAN: Emphasis on contributions toward the National Economic Development objective (Section IV, pages 63 and 64).

1. It is noted that although the first cut NED plan is directed towards increasing the NED benefits over and above the initial plan, it is not a final form NED plan. Its main purpose is to provide a starting point for developing a set of NED plans.

2. The first cut NED plan is developed by joint consideration of the components of the NED objective in the P&S and the initial plan. It is oriented towards investigating how the initial plan can be improved for each component within the specific Maui setting.

3. Presentation of the first cut NED plan starts with an analysis of the initial plan in terms of the opportunities available for increasing goods and services, and reducing the costs associated with providing water supply on Maui. Subsequently the assumptions for modifying the initial plan are stated. The changes which result from applying these assumptions are then indicated and related to the initial plan. Changes include demand at various demand centers, use of supply sources, and allocation of supply sources to demand centers.

(continued on page 151)

1. Increased Goods and Services

a. Opportunities for Improving NED

- **Increased Intensity of Water Use**

  With the assumptions on application rates as stated in the initial plan, the adequacy of irrigation is around 70 percent and therefore production can be increased by additional water application. In Lahaina additional basal groundwater is available for the cost of pumping since capacity is 45 mgd. It is estimated that increased irrigation of 10 percent results in increased sugar production of 5 percent. Comparison of the pumping cost with the additional sugar produced indicates that this assumption is economically feasible.

- **Resort Development**

  Demand projections for resort development are based on individual projections of private developments. These are judged to be on the optimistic side and no faster growth is likely.

- **Kula Development**

  In the Kula area there is a sizeable amount of arable land that, with good farming practices, could be put to productive use. The available acreage is 930 with slight limitations for crop land; with moderate limitations it is 12,270 as derived by the Soil Conservation Service. If it is assumed that this land will be in productive use, the result is an increased demand of about 9 mgd, based on results presented in the report "An Assessment of the Kula Water Situation."

b. Assumptions for Modifying Initial Plan

- Irrigation for Pioneer Mill is increased by 10 percent.
- Demand for resort development remains unchanged.
- Irrigation demands for Kula are increased by 9 mgd.

(continued on page 145)

2. Reduction in Cost

a. Cost Assumptions

Note:

To arrive at estimates of water supply development costs, estimates of distances and elevation differences between demand and supply centers are made. The results are presented in the table on page 64.

- The capital costs of source development, of transmission lines and of treating surface water for domestic use are estimated. Results are presented in the right hand column in the table on assumed cost on page 149.

- The present value of the cost of energy needed to pump water from supply sources to demand centers is presented in the table on assumed cost on page 149. The following assumptions are used:

  - Pumping of one mgd by one foot with an efficiency of .75 requires 4.2 kwh.

  - Total lift used is equal to elevation difference plus one foot per 1,000 feet of transmission to account for friction losses.

  - Cost per kwh is $0.03.

  - Present value is based on 30-year life and 7 percent discount rate.

(continued on page 151)

Differences in Distance/Elevation Between
Demand Centers and Supply Sources
(in 1,000 ft. and ft., respectively)

DEMAND / SUPPLY	Lahaina Domestic	Pioneer Mill	Wailuku Domestic	Wailuku Sugar	HC&S	Kula	Kihei
LAHAINA							
High Groundwater	15/100	11/100					
Basal Groundwater		0/500					
Streamflows		0/0					
Wastewater		5/200					
WAILUKU							
High Groundwater							
Basal Groundwater			0/500	5/500			60/600
Streamflows			0/0	0/0	0/0		
Wastewater				5/200			
Central Basal Groundwater			6/200		0/200		40/300
Kihei Wastewater					10/300		
East Maui Streamflows					0/0	0/200	50/0
Big Springs			1/800		1/800		

ASSUMED COSTS

SUPPLY \ DEMAND	Present Value of Energy Cost Per mgd in $1,000							Capital Cost Per mgd in $1,000 Source+Pipeline+Treatment
	Lahaina Domestic	Pioneer Mill	Wailuku Domestic	Wailuku Sugar	HC&S	Kula	Kihei	
LAHAINA								
High Groundwater	66	63						270[1]
Basal Groundwater		285						240[1]
Streamflows		0						0 + 0 + 300[4]
Wastewater		117						150 + 40[2] + 0
WAILUKU								
High Groundwater								1,000
Basal Groundwater			285	288			377	150 + 480[3] + 0
Streamflows			0	0	0			0 + 0 + 300[4]
Wastewater					117			150 + 40[2] + 0
Central Basal Groundwater			117		114		194	0 + 320[3] + 0
Kihei Wastewater					177			150 + 80[2] + 0
East Maui Streamflows					0	114	28	0 + 400[3] + 300[4]
Big Spring			457		457			150 + 8 + 300[4]

1. Includes source development and pipeline; for basal only if larger than 45 mgd.
2. Based on 36" pipeline (10 mgd) at $80/foot.
3. Included if pipeline is necessary to connect Kihei to supply source.

b. Opportunities for Cost Reduction

- HC&S uses only 23 of the 28 mgd remaining in Wailuku streamflows for water supply. Since use of streamflows for irrigation requires no pumping, and in the initial plan Big Spring requires pumping of 800 feet, the overall costs can be reduced by increasing the HC&S supply from Wailuku streamflows.

- The 13,000 acres of HC&S not converted to drip irrigation is in the lower areas served by basal groundwater. Water savings from conversion reflected by a reduction in demand at HC&S of 26 mgd and in the supply of Central Basal groundwater of 6 mgd, do not benefit HC&S because the water saved would have to be pumped to irrigate new sugar cane fields at high elevations. However, these water savings could be used to serve Kihei. Assuming no extra pumping cost for HC&S, and using the assumed cost data on the previous page, the following comparison is made (in $1,000).

		Initial Plan	Modification
Kihei:	Capital cost	$11,340	$ 5,760
	Energy cost	6,786	3,492
Cost of Drip Irrigation at $500/acre for 13,000 acres			6,500
		$18,126	$15,752

Thus the modification would result in a cost savings.

c. Assumptions for Modifying the Initial Plan

- HC&S uses 28 mgd from Wailuku streamflows.

- Drip irrigation is implemented 100 percent.

- Kihei is supplied by Central Basal groundwater.

4. The feasibility of the suggested changes in water use by HC&S, both in terms of drip irrigation and use of supply sources, is not investigated in detail at this stage. In the aggregate, however, feasibility is assumed and the implications of such changes are investigated. Results of that investigation provide a basis for further analysis.

(continued on page 154)

FIRST CUT NED PLAN: Changes in Demand, Supply and Allocation

1. Changes in Demand

- The demand at Pioneer Mill is increased from 81 mgd to 89 mgd due to more intensive use of water.
- The demand at HC&S is decreased from 303 mgd to 277 mgd due to increased application of drip irrigation.
- The Kula demand is increased from 6 mgd to 15 mgd due to increased agricultural production.

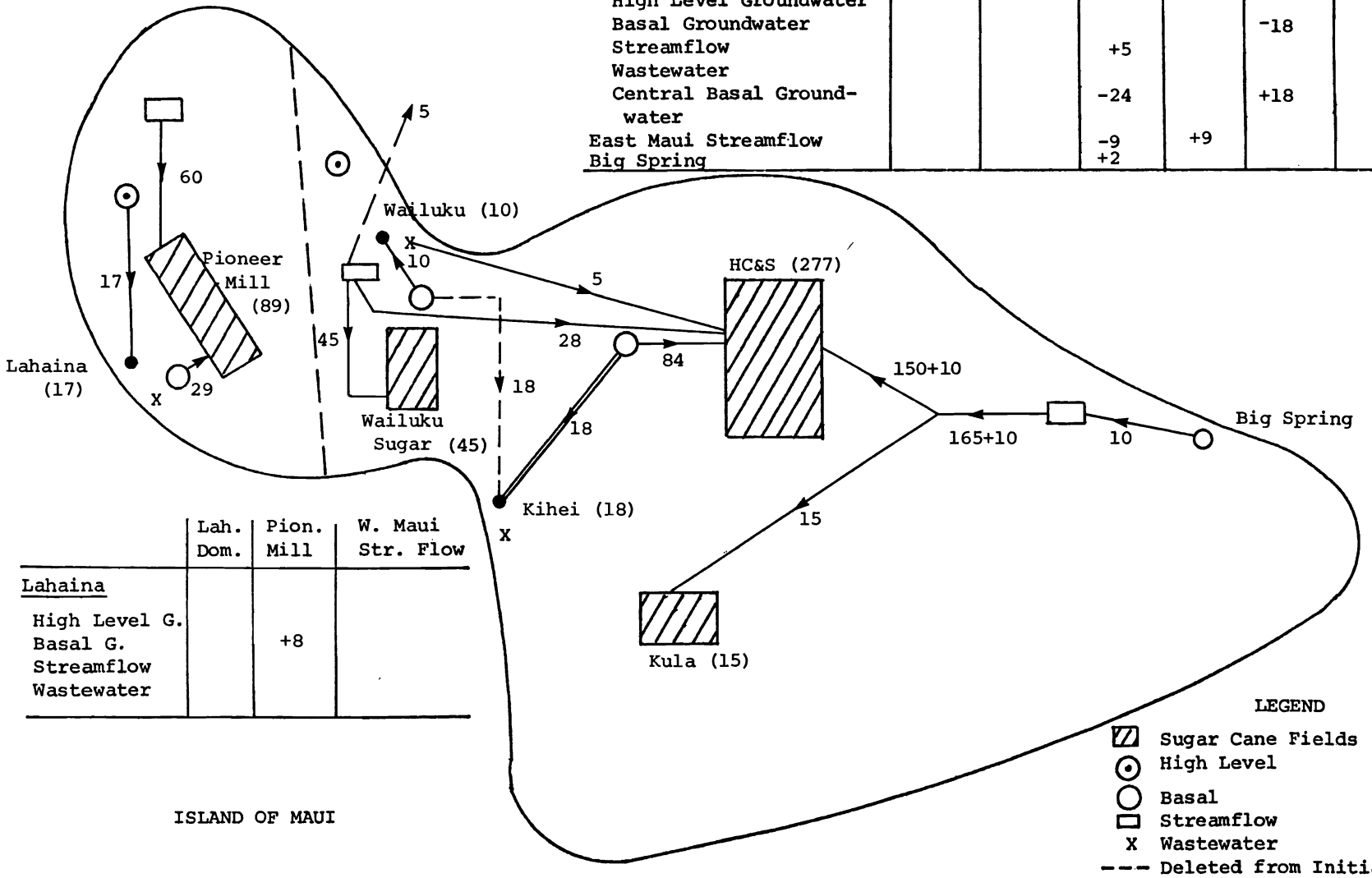
2. Changes in Supply

- The use of Central Basal groundwater is reduced from 108 mgd to 102 mgd due to increased application of drip irrigation.

3. Allocation of Supply to Demand

- Pioneer Mill: The 10 percent increase in demand is supplied by basal groundwater.
- Kula: The increase in Kula demand is supplied by East Maui streamflows.
- Kihei: The demand at Kihei is supplied by Central Basal groundwater.
- HC&S: All remaining supplies from Wailuku and East Maui streamflows and from Central Basal groundwater are used first to satisfy HC&S demand; wastewater from Wailuku is used next; finally the demand is met by supply at Big Spring, used to capacity.

	Wailuku Dom.	Wailuku Sugar	HC&S	Kula	Kihei	E. Maui Streamflow
Wailuku						
High Level Groundwater						
Basal Groundwater					-18	
Streamflow			+5			-5
Wastewater						
Central Basal Groundwater			-24		+18	
East Maui Streamflow			-9	+9		
Big Spring			+2			



	Lah. Dom.	Pion. Mill	W. Maui Str. Flow
Lahaina			
High Level G.			
Basal G.		+8	
Streamflow			
Wastewater			

LEGEND

- Sugar Cane Fields
- High Level
- Basal
- Streamflow
- X Wastewater
- Deleted from Initial
- Same as Initial
- Added to Initial
- 84 mgd Transported
- (15) mgd Demanded

FIRST CUT NED PLAN: Deviations from Initial Plan

PHASE 3

		NED a	
	First Cut NED		Selected NED
		NED b	Comparison
→	First Cut EQ No. 1		Selected EQ of
		NED c	Plans
	First Cut EQ No. 2		Mixed Obj. Plan
		EQ a	
		EQ b	

FIRST CUT EQ PLAN NO. 1: Emphasis on contributions towards the Environmental Quality objective. (Section IV, pages 17 and 18).

1. Development and presentation of the First Cut EQ Plan No. 1 follows the same structure as the First Cut NED Plan. Thus, the initial plan is analyzed for possible improvements from an EQ perspective: (1) the environmental problems associated with the initial plan will be analyzed; (2) modifications to alleviate these problems are proposed; and (3) the new allocation of supply sources to demand centers is presented.

(continued on page 160)

FIRST CUT EQ PLAN NO. 1: Analysis of Initial Plan

1. Environmental Problems Associated With the Initial Plan

Environmental Quality Component Categories (From P&S)	Environmental Problems of Initial Plan
. Open and green space, wild and scenic rivers, lakes, beaches, shores, mountains, wilderness areas, estuaries or other areas of natural beauty.	. Further extension of sugar cane in undeveloped areas. . Resort development along beaches.
. Archeological, historical, biological, geological resources and selected ecosystems.	. Elimination of fish and wildlife habitat due to diversion of streams for irrigation. . Destruction of environment associated with drilling wells, building channels and laying transmission pipelines.
. Quality of water, land and air resources.	. Increased pumping requirements results in increased air pollution.
. Irreversible commitment of resources to future uses.	. Permanent change in beach areas used for resort development.

2. Alleviation of Environmental Problems

. Implement drip irrigation on all sugar cane fields, in order to minimize needs for further development of supply sources in environmentally sensitive areas.

. Limit sugar cane to the present acreage, in order to maintain open space.

. Reduce diversion from streamflows in order to provide needed minimum streamflows during the summer.

. Leave domestic use which is mainly associated with resort development the same based on the assumption that resort development will enhance an otherwise unattractive environment, e.g., at Kihei.

. Use existing sources more efficiently; then start new developments.

(continued on page 159)

2. The case study is performed on an annual basis for reasons explained in Comment 3 on page 132. Therefore, to represent minimum streamflow restrictions in the summer, an equivalent average annual measure is used.

3. Assumptions for Modifying the Initial Plan

- Drip irrigation is implemented 100 percent.
- Sugar cane acreage remains at present levels.
- Domestic demand in initial plan remain unchanged.
- The fish and wildlife instream demand for water in the summer months is equivalent to 15 percent of the average annual streamflow.

FIRST CUT EQ PLAN NO. 1: Changes in Demand, Supply and Allocation

1. Changes in Demand

- The demand at Pioneer Mill decreases from 81 to 72 mgd and the demand at Wailuku Sugar from 45 to 40 mgd, both due to increased application of drip irrigation; the demand at HC&S decreases from 303 to 248 mgd due to increased application of drip irrigation and due to elimination of a 3,600 acre increase in total sugar cane acreage.

- The fish and wildlife demand for instream use in West Maui streams is 9 mgd, in Wailuku streams 11 mgd, and in East Maui streams 25 mgd.

2. Changes in Supply

- Basal groundwater is reduced from 65 to 63 mgd for Lahaina, from 29 to 28 mgd for Wailuku, and from 108 to 102 mgd for Central Basal due to increased application of drip irrigation.

3. Allocation of Supply to Demand

- Pioneer Mill: The supply from streamflows is reduced by 9 mgd to satisfy minimum streamflow requirements which is balanced by the demand reduction resulting from 100 percent use of drip irrigation.

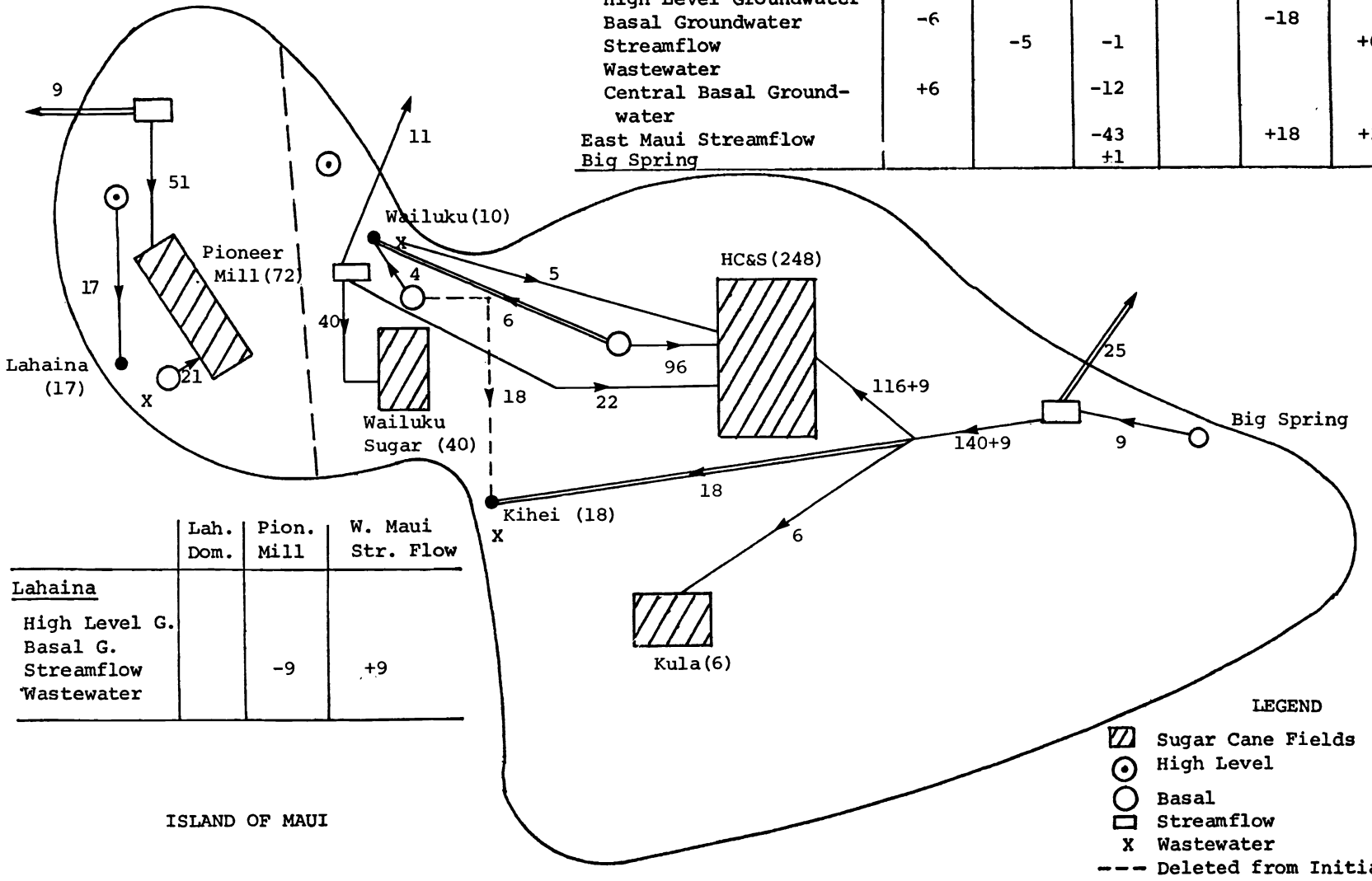
- Wailuku Domestic: The increase in future demand is supplied by existing Central Basal instead of new Wailuku basal development.

- Wailuku Sugar: The demand is reduced but the supply source remains the same.

- Kihei: The demand is supplied with water from East Maui streamflows instead of new basal development in Wailuku.

- HC&S: All sources remain about the same except Central Basal which is reduced by 12 mgd and East Maui streamflows which is reduced by 43 mgd.

	Wailuku					E. Maui Stream-flow
	Dom.	Sugar	HC&S	Kula	Kihei	
Wailuku						
High Level Groundwater						
Basal Groundwater	-6				-18	
Streamflow		-5	-1			+6
Wastewater						
Central Basal Groundwater	+6		-12			
East Maui Streamflow			-43		+18	+25
Big Spring			+1			



	Lah. Dom.	Pion. Mill	W. Maui Str. Flow
Lahaina			
High Level G.			
Basal G.			
Streamflow		-9	+9
Wastewater			

LEGEND

- Sugar Cane Fields
- High Level
- Basal
- Streamflow
- X Wastewater
- Deleted from Initial
- Same as Initial
- Added to Initial
- 84 mgd Transported
- (15) mgd Demanded

FIRST CUT EQ PLAN NO. 1: Deviations from Initial Plan

PHASE 3

	NED a		
First Cut NED		Selected NED	
	NED b		Comparison
First Cut EQ No. 1		Selected EQ	of
	NED c		Plans
→ First Cut EQ No. 2		Mixed Obj. Plan	
	EQ a		
	EQ b		

FIRST CUT EQ PLAN NO. 2: Emphasis on contributions towards the Environmental Quality objective (Section IV, pages 63 and 64.

1. The type and number of first cut plans developed during this phase depends on the planning situation rather than on any generally applicable rules. In Maui it was considered sufficient to develop one First Cut NED Plan. However two First Cut EQ plans were developed to assure proper consideration of the Environmental Quality objective. The need for a second First Cut EQ plan is generally reinforced because the initial plan is biased toward primarily economic considerations.

2. The objective of the First Cut EQ Plan No. 2 is to identify any environmental concerns or opportunities related to the provision of water supply on Maui which were overlooked because of the NED bias associated with the initial plan. Thus, the orientation of the plan is to achieve "maximum" environmental benefits using the water supply plan as a means towards improving the environment while satisfying demands. The plan is developed starting without the initial plan to allow for the development of EQ alternatives that cover a wider range of possible impacts.

3. Development of the First Cut EQ Plan No. 2 in this particular case is structured as follows: (1) Problems and opportunities in Maui, related to component categories of the EQ objective that bear some relationship to the provision of water supply, are investigated. (2) The complete range of development alternatives for water supply sources are then investigated in terms of expected environmental consequences. (3) Possible demand changes are examined based on strictly environmental considerations. (4) Based on (2) and (3) a set of assumptions

(continued on page 166)

FIRST-CUT EQ PLAN NO. 2: Environmental Problems and Opportunities for Improvement

Environmental Quality Component Categories (from P&S)	Existing Environmental Issues Related to Provision of Water Supply on Maui	Opportunities for Environmental Enhancement through Changes in the Provision of Water Supply on Maui
1. Open and green space, wild and scenic rivers, lakes, beaches, shores, mountains, wilderness areas, estuaries or other areas of natural beauty.	Frequent draining of reservoirs for agricultural irrigation. Intrusion on forest reserves at high elevations for water resource development. Visual changes in landscape due to ditches, etc. Upper Iao Valley, a significant environmental area, threatened by development.	Increase in water supply to the Kula area could provide a more diversified environment.
2. Archeological, historical, biological, geological resources and selected ecosystems.	Elimination of critical fresh water F&W habitat due to diversion of streams. Diversion threaten integrity of forest ecosystems by increased penetration of pristine areas; introduction of exotics. Groundwater infiltration associated with irrigation methods.	Augmentation of streamflows could enhance fish and wildlife.
3. Quality of Water, Land and Air Resources	Quality of ditch water unsafe for drinking. Increase in sugar production due to increase in water for irrigation may coincide with increase in air pollution from burning high sulphur oil.	Integrated water supply and wastewater systems could eliminate pollution problems and intrusion in the landscape resulting from extensive separate transmission systems.
4. Irreversible commitment of resources to future uses.	Provision of water for resort development is one cause of permanent change.	Resort development can enhance an otherwise inhospitable environment.

is formulated that begins to address the problems and opportunities identified under (1). (5) Finally, based on these assumptions, supply sources are allocated to demand centers.

4. A key difficulty encountered in the case study was the identification of EQ problems and opportunities that, in fact, could be related to water supply planning on Maui. Since emphasis is to be placed on this relationship in developing a First Cut EQ plan, discussion with the public and environmental experts is needed to clearly delineate such problems.

(continued on page 170

ADVANTAGES AND DISADVANTAGES OF WATER SUPPLY DEVELOPMENT ALTERNATIVES
FROM AN ENVIRONMENTAL PERSPECTIVE

Water Supply Development Alternative	Advantages	Disadvantages
1. Surface Water Development	Flood and erosion control; creation of fisheries and recreation; stream flow attenuation; low energy requirements.	Physical and ecological disturbances; depletion of surface waters; intrusion on visual quality and open space.
2. Groundwater	Minimal surface distrubances; minimal ecological effects.	High energy requirements.
3. Desalination	Preservation of freshwater sources; moderate surface and ecological disturbances.	High energy requirements; brine disposal problems.
4. Water Reuse	Conservation of water resources; preservation of high-quality waters for domestic uses; no increased surface and ecological disturbances.	Requires wastewater collection and treatment facilities; low public acceptability.
5. New Irrigation Methods	Conservation of water resources; no increased surface and ecological disturbances.	Dependent upon private implementation.
6. Weather Modification	Net increase in available water resources; redistribution of atmospheric precipitation where desired.	Full effects not presently predictable; methods not always reliable.

FIRST CUT EQ PLAN NO. 2: Assumptions and Allocation of Supply to Demand

1. Assumptions for Plan Development

- Implement drip irrigation on all major fields in order to minimize need for further development of supply sources.
- Supply an additional 9 mgd to the Kula area in order to enhance diversity of the environment. The additional demand is based on an estimated increase in agricultural needs.
- The domestic demand assumptions are based on projections made for resort areas in the initial plan.
- The available supply is the same as assumed for the initial plan.
- Water is reused for domestic needs by designing integrated systems to conserve water instead of maintaining separate water supply and wastewater systems.
- From an environmental perspective a preference order for supply alternatives is established based on considerations on the previous page.

  (1) Basal Groundwater. This is preferred over high elevation groundwater to prevent intrusion into natural areas. Basal is also preferred over surface water withdrawal because of ecological effects associated with the latter.

  (2) Surface Water Development. Up to 50 percent of runoff is allowed. This alternative is preferred over high level groundwater development.

  (3) Desalination. Desalination is preferred over high level groundwater.

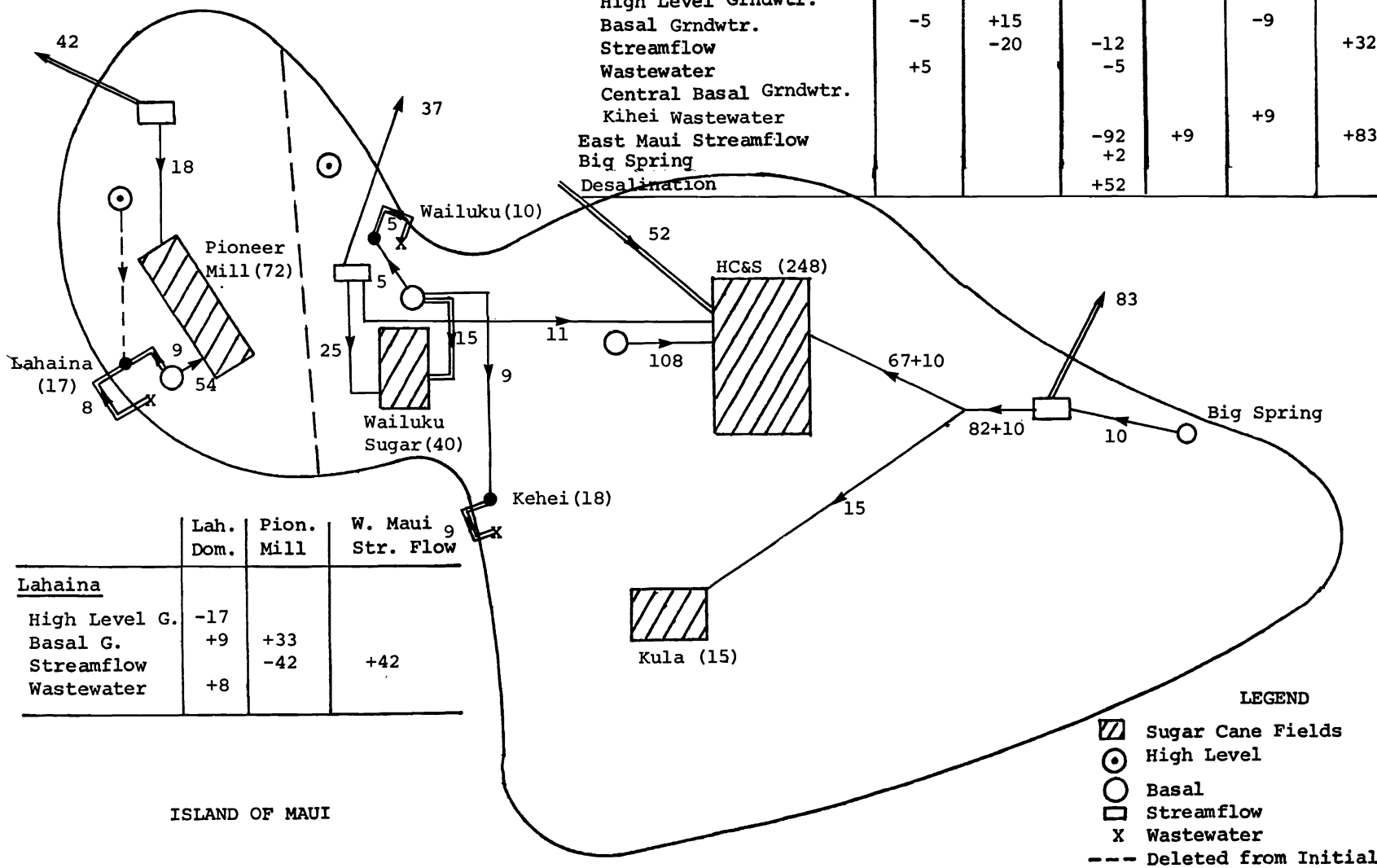
- Energy requirements for pumping are not considered to be a major problem because waste products from sugar cane are available for energy generation and there are opportunities for developing solar energy and wind power within the timeframe of the plan.

2. Allocation of Supply to Demand

- Use basal groundwater to satisfy the part of domestic demand which is not satisfied by reuse of wastewater.
- Use East Maui streamflows to satisfy Kula demand and Big Spring for HC&S irrigation requirements.
- Use all basal groundwater, then streamflows up to 50 percent and finally desalination for sugar cane irrigation requirements.

5. It is noted that the plan displayed differs significantly from the plans presented so far; as such it satisfies the purpose of enlarging the total range of water supply plans considered. Further plan formulation efforts will be necessary in order to identify short-term water supply decisions that are directed towards improving the environment.

	Wailuku					E. Maui Stream-flow
	Dom.	Sugar	HC&S	Kula	Kihei	
Wailuku						
High Level Grndwtr.						
Basal Grndwtr.	-5	+15			-9	
Streamflow		-20	-12			+32
Wastewater	+5		-5			
Central Basal Grndwtr.						
Kihei Wastewater					+9	
East Maui Streamflow			-92	+9		+83
Big Spring			+2			
Desalination			+52			



	Lah. Dom.	Pion. Mill	W. Maui Str. Flow
Lahaina			
High Level G.	-17		
Basal G.	+9	+33	
Streamflow		-42	+42
Wastewater	+8		

FIRST CUT EQ PLAN NO. 2: Deviations for Initial Plan

1. The memorandum shown on the opposite page is prepared by the water supply team to provide the study manager with the information needed to decide which team should be responsible for developing specific recommendations involving various functions. It is based on a preliminary review by each team of the specifics of the interface after completing their First Cut plans. Thus in addition to the input from the water supply team, similar input is provided by the water quality and wastewater management, and the fish and wildlife teams.

2. Following the study manager's review of the First Cut plans and the respective recommendations concerning the interface by the teams involved, it was decided that the water supply team would assume responsibility for developing recommendations regarding wastewater reuse; the water quality and wastewater team would provide the necessary inputs on cost data and quality differences of various treatment and disposal alternatives. Thus, the water supply team was charged with multifunction planning involving water supply, water quality and wastewater on Maui. With respect to the interface between water supply and fish and wildlife, the study manager concurred with the recommendation made by the water supply team. It was decided that the fish and wildlife team would use the First Cut EQ water supply plans and develop an alternative (EQ c) plan with special emphasis on providing a recommendation on the level and location of minimum streamflow requirements.

3. In the Maui case study proposals of wastewater reuse for irrigation were initiated because of the cost savings features although it also has environmental quality consequences. For this reason wastewater reuse is further analyzed using the First Cut NED plan as a starting point. This choice is not crucial; i.e., development of the "multifunctional" plan could also have been started from the EQ plan. The overriding consideration is that the various plans developed in the study should cover the range of feasible alternatives. Different planners may arrive at different plans following different routes, but in the end the plans may be expected to cover the same range.

MEMORANDUM

To: Study Manager

From: Water Supply Team

Date: June 23, 1975

Subject: Water Supply Interface With Water Quality and Wastewater Management, and With Fish and Wildlife

---

A. Interface With WQ and WWM

The water supply study team has concluded that further investigation of the interface between WS and WQ and WWM should include analysis of: (1) the possibility of reusing wastewater for irrigating Wailuku sugar cane fields, as shown in the initial plan; and (2) the reuse to Lahaina and Kihei. This analysis should address both an economic evaluation of wastewater reuse, and an assessment of its affect on sugar cane quality.

If it is decided that the WS team is responsible for developing the recommendation for reuse of wastewater the following information will be needed from the WQ and WWM team:

- Identification and cost of alternatives for disposal of effluent (e.g., injection wells).

- Determination of effluent quality using alternative treatment facilities and the cost associated with each.

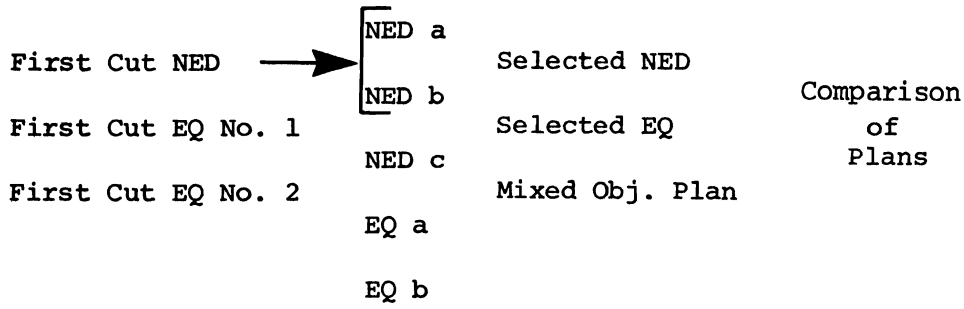
It is recommended that the water supply team takes the responsibility for recommendations concerning reuse of wastewater for sugar cane irrigation.

B. Interface With F&W

It has been concluded that further investigation of the interface between WS and F&W should include analysis of: (1) implications for water supply of demands on instream surface water for use by fish and wildlife; and (2) location of the most urgent demands and the affects of satisfying such needs. While the implications of satisfying demands for instream surface water can be analyzed by the WS team, the second issue is beyond the expertise available on the team. It is therefore recommended that the F&W team be made responsible for developing the minimum streamflow requirements recommendation, with the WS team furnishing the following information:

Effects of various demand levels for instream surface waters on choice and cost of water supply system.

PHASE 3



NED a AND NED b: Emphasizing uncertainties in the irrigation demand for water (Section IV, page 65 .

1. Alternative NED plans are formulated in order to study the sensitivity of the First Cut NED plan to uncertainty in the application rate of drip irrigation. NED a assumes a low application rate, while NED b assumes a high rate. One or more representative plans are to be selected for public presentation together with their implication in terms of decisions for a short-term plan and a program of investigations.

2. Modifications are considered separately for the Lahaina and Central Maui system because the two systems do not interact and because analysis is simplified by considering the two independently.

3. In selecting an alternative to the First Cut NED plan, emphasis should be placed on covering the range of realistic NED plans for the year 2000 rather than on selecting the "best" NED plan. The number of alternative plans depends on the situation. Thus in Maui the uncertainty in application rates of drip irrigation led to two alternative plans. It is reemphasized that the modified plans are used to determine which short-term decisions are associated with year 2000 plans and how such decisions can ensure or limit the future choice of a year-2000 plan. Thus plans for the year 2000 provide the framework within which short-term decisions are made.

1. Basis for Modifying the First Cut Plan

Possible variations in domestic demand are relatively small as compared to agricultural demand changes. For this reason there is no need to change assumptions for domestic demand.

Agricultural demand may vary substantially because of uncertainty in irrigation requirements for a given output per acre or in increased requirements for increases in output per acre. For this reason the following modified assumptions are investigated for NED a and NED b plans, respectively.

(1) To produce 7.25 tons per harvested acre per year, only 6,200 gallons/acre/day are required with drip irrigation instead of the 8,000 assumed; with the same 10 percent increase in irrigation as in the first cut plan this reduces demand from 89 to 80 mgd.

(2) It is economically desirable to increase irrigation 20 percent above the level assumed in the initial plan in order to produce more sugar; this increases demand from 89 to 97 mgd.

2. Alternative Plans

In both of the above cases, the difference is in the amount of basal groundwater used. In the case of lower application rates use of basal groundwater is reduced from 29 to 20 mgd and in the case of higher application rates it is increased from 29 to 37 mgd. It is therefore concluded that the water supply system for the Lahaina area does not change significantly as a result of changes in agricultural demand. Thus NED a and NED b remain the same as in the First Cut plan.

MODIFICATIONS TO FIRST CUT NED PLAN: Central Maui System

1. Basis for Modifying the First Cut Plan

- Possible variations in domestic demand are relatively small as compared to agricultural demand changes and are therefore not considered.

- Agricultural demand may vary substantially because of uncertainties in required application rates for drip irrigation. For this reason the following modified assumptions are investigated for NED a and NED b plans, respectively:

  (1) To produce 7.25 tons per harvested acre per year, only 6,200 gallons/acre/day are required with drip irrigation rather than the 8,000 assumed; this reduces the demand given in the first cut plan for Wailuku Sugar from 45 to 41 mgd, and at HC&S from 277 to 215 mgd.

  (2) It is economically desirable to increase drip irrigation application rates above those assumed in the initial plan (i.e. 8,000 to 9,000 gallons/acre/day) in order to produce more sugar; this increases demand at Wailuku Sugar from 45 to 48 mgd, and at HC&S from 277 to 311 mgd. Agricultural demand is reduced for the Kula area to the value shown in the initial plan in order to reflect the emphasis on sugar cane production.

2. NED a: Reduced Irrigation Requirements

The NED a plan, presented on the top of page 179 uses the following allocation sequence:

(1) Wailuku streamflows are used to satisfy Wailuku Sugar and the remainder goes to HC&S.

(2) East Maui streamflows are used to satisfy Kula and Kihei, while the remainder is used for HC&S; Kihei is supplied by East Maui streamflows because this is the cheaper alternative and also because irrigation reduction made enough water available at high elevation.

(3) Existing capacity of Wailuku basal groundwater is used to satisfy Wailuku Domestic and remainder is satisfied with Central Basal groundwater because capacity is available; remainder of HC&S is satisfied with Central Basal groundwater.

3. NED b: Increased Irrigation Requirements

The NED b plan, presented at the bottom of page 179 uses an allocation sequence quite similar to the initial plan. As expected the differences between this plan and the initial plan are minor.

MODIFICATIONS TO FIRST CUT NED PLAN: Presentation of Alternative Plans

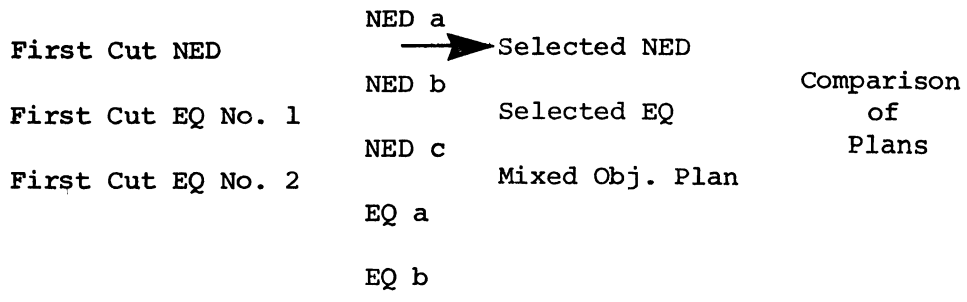
NED a: Reduction in Irrigation Requirements

Supply \ Demand	Wailuku Domestic	Wailuku Sugar	HC&S	Kula	Kihei	Maui Stream Flow	Available Supply
WAILUKU							
High Level Groundwater							10
Basal Groundwater	4						29
Streamflows		41	31				73
Wastewater			5				5
Central Basal Groundwater	6		47				108
Kihei Wastewater							9
East Maui Streamflows			132	15	18		165
Big Spring							10
	10	41	215	15	18		

NED b: Increase in Irrigation Requirements

Supply \ Demand	Wailuku Domestic	Wailuku Sugar	HC&S	Kula	Kihei	Stream Flow	Available Supply
WAILUKU							
High Level Groundwater							10
Basal Groundwater	10				18		29
Streamflows		48	25				73
Wastewater			5				5
Central Basal Groundwater			108				108
Kihei Wastewater			4				9
East Maui Streamflows			159	6			165
Big Spring			10				10
	10	48	311	6	18		

PHASE 3



SELECTED NED PLAN: Based on comparison of the First Cut NED Plan, the NED a Plan and the NED b Plan (Section IV, page 66).

1. One NED plan is selected in the case study and the associated short-term decisions are presented. The short-term decisions will be further investigated in the next phase of the Level B study, where the benefits and costs associated with each decision will be analyzed and trade-offs presented for evaluation by the public.

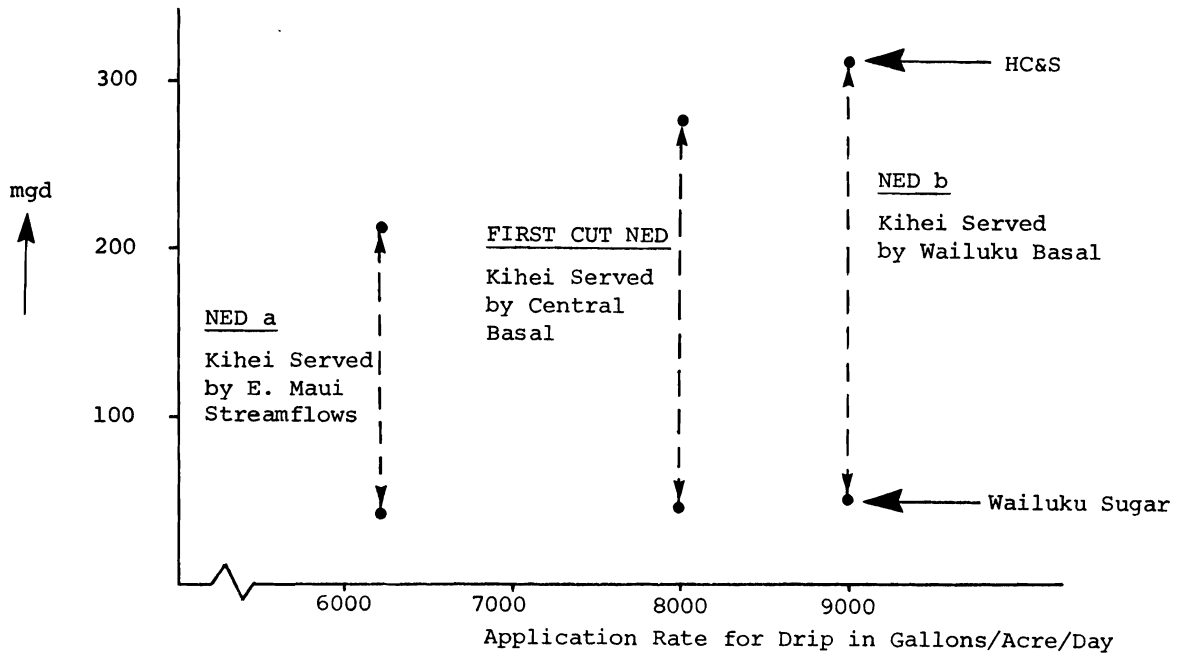
2. In the selection of the NED plan consideration is given to its technical feasibility and institutional viability (see acceptability test in P&S). In this case the lowest application rates for drip irrigation are considered unrealistic by private sugar planters; their cooperation will be needed in developing an overall water supply plan for Maui. For this reason the lowest value is not used in the selected NED plan.

3. It is noted that selection of the NED plan in the case study has been performed by the study team. In reality input from the public is essential in this selection.

4. Differences between the selected NED and the initial plan are summarized in the foldout on page2211.

SELECTION OF NED PLAN: Comparison and Selection

1. Comparison of NED Plans



2. Selection of NED Plan

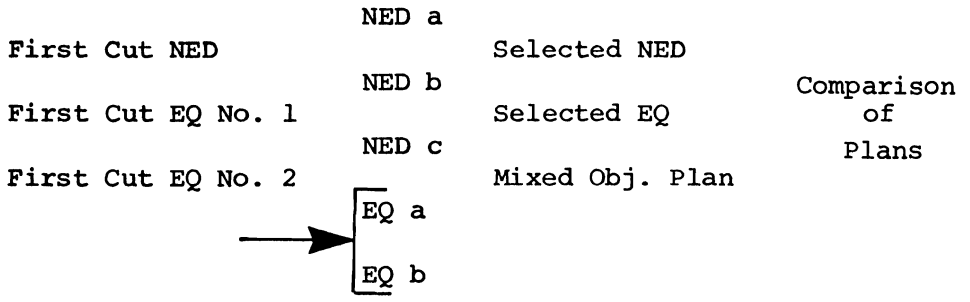
The First Cut NED Plan is selected as the NED Plan because:

- The alternatives to the First Cut Plan provide no basic changes for the Lahaina system.
- The alternative plan for Central Maui with reduced demand (NED a) is not considered realistic because (1) the application rate for drip irrigation is considered overoptimistic by sugar planters and, (2) the savings would come too late to satisfy Kihei demand.
- The alternative plan for Central Maui with increased demand (NED b) is too close to the initial plan and does not present a new alternative.
- The first cut plan presents a different alternative from the initial plan with savings from drip irrigation at lower elevations used to serve Kihei.

3. Implications for Short-Term Decisions

- Develop high level groundwater for Lahaina Domestic.
- Develop additional basal groundwater for Wailuku Domestic.
- Continue diversion of streamflows for irrigation purposes.
- Serve Kihei with basal groundwater from Central Maui.
- Convert low level sugar cane field to drip irrigation.
- Increase supply to Kula for truck farming irrigation.

PHASE 3



EQ a: Emphasis on improving the environmental aspects associated with the First Cut EQ Plans (Section IV, page 65).

1. An alternative to the First Cut EQ plans was developed because it was felt that First Cut EQ Plan No. 1 could be improved by using some of the features of First Cut EQ Plan No. 2

2. After the study manager decided that the fish and wildlife team would be responsible for preparing a recommendation on location and quantity of minimum streamflow requirements, the water supply team did not pursue the development of EQ b which was specifically directed towards this interface.

MODIFICATION OF FIRST CUT EQ PLANS: EQ a

1. Basis for Modifying First Cut Plans

- Additional basal groundwater is available to replace the diversion from streamflows; since use of basal groundwater has less environmental impact than diversion from streamflows, all basal groundwater is used first in the alternative to the First Cut EQ plans.

- Wastewater reuse can also be used to reduce the need for streamflow diversion, and is by itself preferrable from an environmental viewpoint. In EQ a wastewater will be used first to irrigate sugar cane.

- Further reduction in the need for streamflow diversion is achieved by conversion of all sugar cane to drip irrigation, limiting sugar cane to presently developed acreage and not increasing agricultural demand at Kula above 6 mgd. Based on this conversion and limitation, the demands for domestic and agriculture are as given in First Cut EQ Plan No. 2.

2. EQ a

EQ a is presented in the next page and uses the following allocation sequences.

(1) Wastewater is used to irrigate sugar cane fields, i.e., wastewater from Lahaina for Pioneer Mill, from Wailuku for Wailuku Sugar, and from Kihei for HC&S.

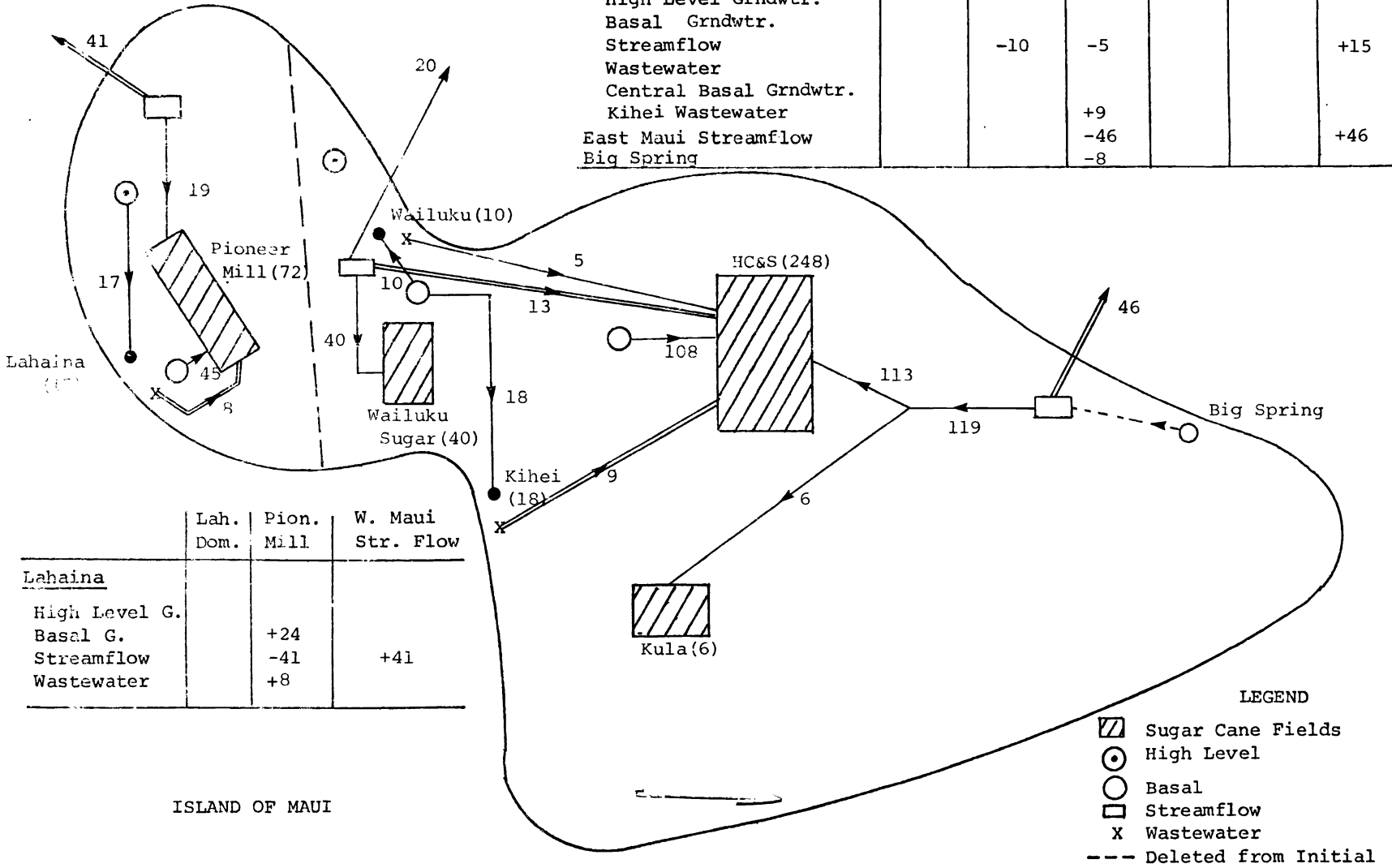
(2) Lahaina Domestic, Wailuku Domestic and Kihei are served by groundwater, and Kula by East Maui streamflows as in the initial plan.

(3) Existing capacity of 45 mgd basal groundwater in Lahaina is used for Pioneer Mill; the remainder of 19 mgd is served by streamflows, so that the residual instream use is 41 mgd.

(4) Remainder for Wailuku Sugar is served by Wailuku streamflows, and all Central Basal groundwater is used for HC&S; the remainder for HC&S is served by streamflows from Wailuku and East Maui in such a way that for each the same percentage of available supply is diverted.

1. Compare the EQ a plan with the plan on page 211.

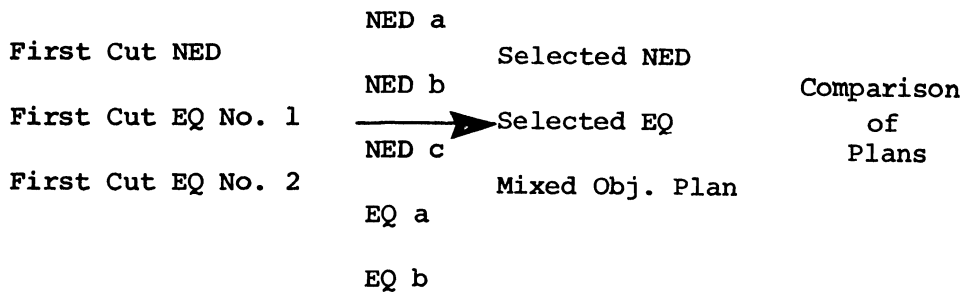
	Wailuku					E. Maui Stream-
	Dom.	Sugar	HC&S	Kula	Kihei	flow
Wailuku						
High Level Grndwtr.						
Basal Grndwtr.						
Streamflow		-10	-5			+15
Wastewater						
Central Basal Grndwtr.						
Kihei Wastewater			+9			
East Maui Streamflow			-46			+46
Big Spring			-8			



	Lah. Dom.	Pion. Mill	W. Maui Str. Flow
Lahaina			
High Level G.			
Basal G.		+24	
Streamflow		-41	+41
Wastewater		+8	

EQ a: Deviations from Initial Plan

PHASE 3



SELECTED EQ PLAN: Based on comparison of the First Cut EQ Plans and EQ a (Section IV, page 66).

1. As shown on the opposite page comparison of plans at this stage may be performed in terms of displaying the differences in physical characteristics of the plan which provide an insight to the associated impacts.

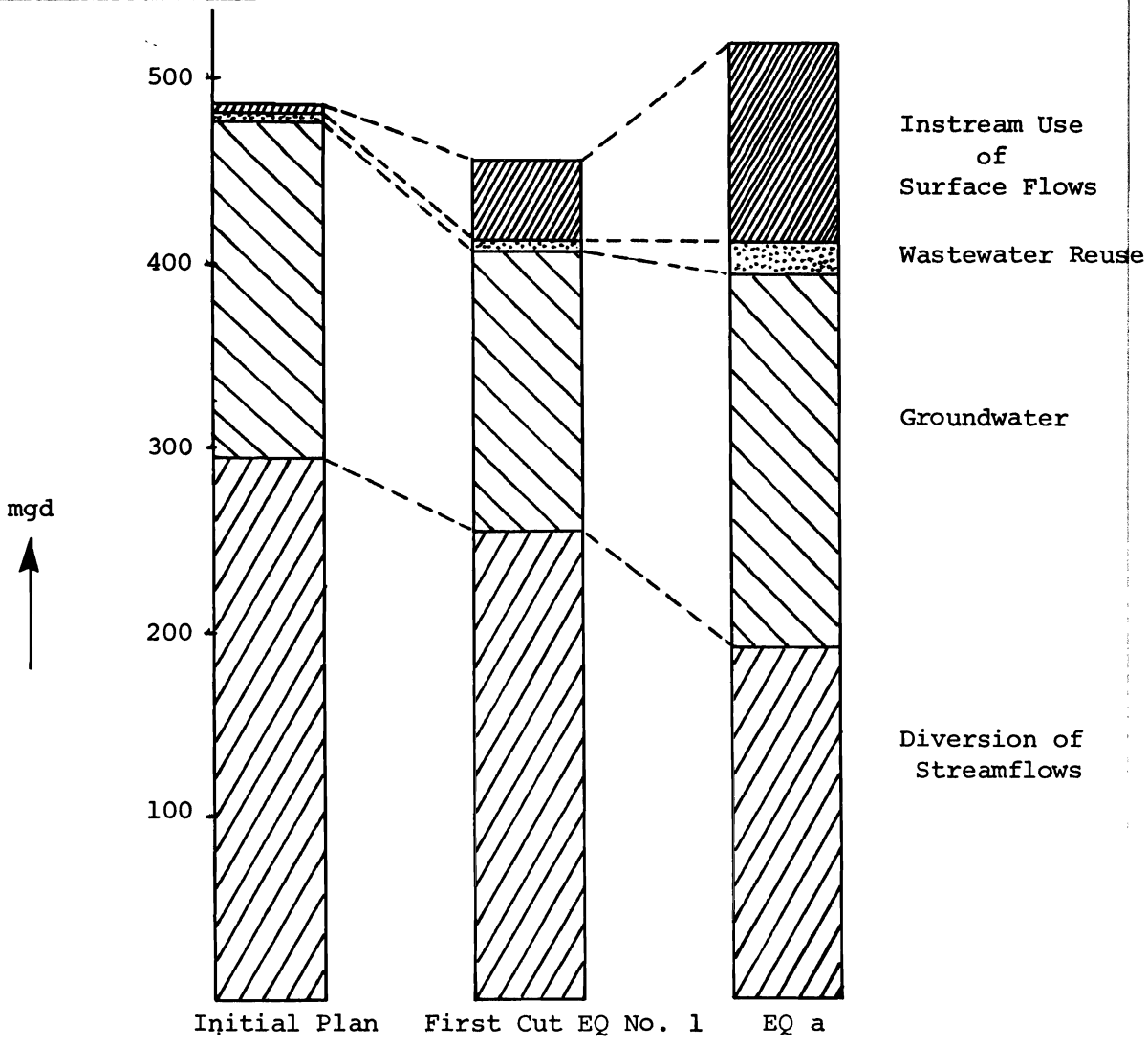
2. Similar to the selection of the NED plan the input of the public in selecting the EQ plan that will be carried forward in the assessment of impacts, is essential. For purpose of the case study the selection has been made by the study team.

3. The EQ b plan developed by the fish and wildlife team would be used here in selecting the EQ Plan. For the case study, however, the EQ b plan was not available and its use is therefore not illustrated.

4. In the foldout on page 211 the differences between the selected EQ and initial plan are summarized.

SELECTED EQ PLAN: Comparison and Selection

1. Comparison of Plans



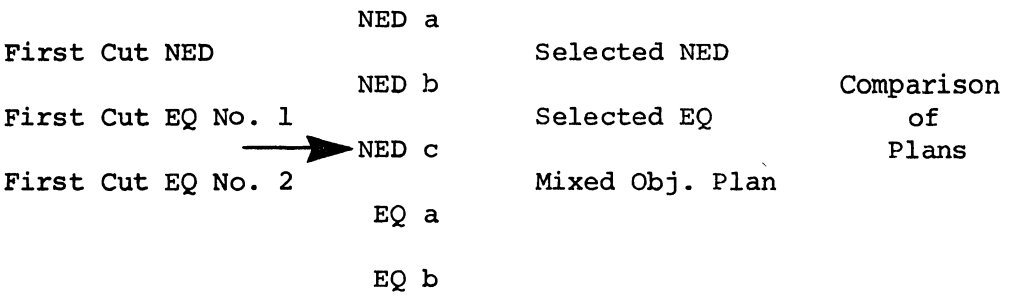
2. Selection of EQ Plan

The modified EQ Plan is chosen over either of the two First Cut plans because: (1) it provides improved consideration of environmental concerns addressed in the First Cut EQ Plan No. 1, such as the instream use of surface water and wastewater reuse, and (2) it is more realistic than First Cut Plan No. 2 with respect to the feasibility of actions necessary to implement that Plan.

3. Short-Term Decisions

- Start development of high level groundwater in Lahaina.
- Investigate feasibility of wastewater use for sugar cane irrigation.
- Decide on size of diversion for different streams.
- Decide limitations on expansion of sugar cane fields.
- Decide on full implementation of drip irrigation.

PHASE 3



NED c: Emphasis is on the interface between water supply, and water quality and wastewater (Section IV, page 65).

1. The purpose of NED c is to analyze the use of wastewater for sugar cane irrigation on Maui so that the water supply team can prepare a recommendation regarding its use to be included in the recommended Level B plan.

2. The interface between water supply, and water quality and wastewater management is analyzed by first considering the Initial Plan for WQ and WWM. Then opportunities for combining WS, and WQ and WWM, (i.e., use of effluent for sugar cane irrigation),are investigated and the plan is formulated.

3. In the analysis, the interface input from the WQ and WWM team was essential for assessing the economic desirability of pursuing wastewater reuse.

4. The differences between NED c and the Initial Plan are summarized in the foldout on page 211.

MODIFICATIONS OF FIRST CUT NED PLAN:
NED c, Analysis of Wastewater Reuse

1. Initial Wastewater Plan

Location	Initial Plan
Lahaina	. Eliminate ocean outfalls. . Install wastewater treatment plant. . Method for effluent disposal not available.
Wailuku	. Eliminate ocean outfalls. . Install wastewater treatment plant. . Use injection wells for disposal of effluent.
Kihei	. Install wastewater treatment plant. . Method for effluent disposal not available.

2. Interrelationship

Wastewater: Disposal of effluent not resolved

Water Supply: Demand for irrigation water for sugar cane fields

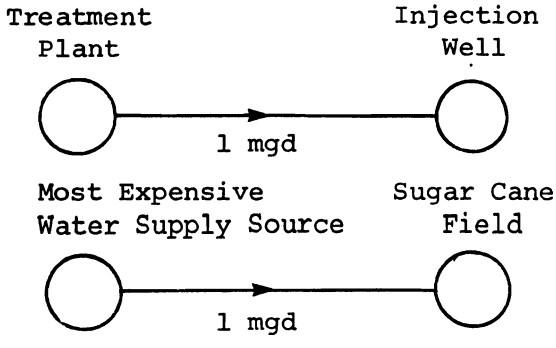
Use effluent to irrigate sugar cane fields

3. Cost Implications

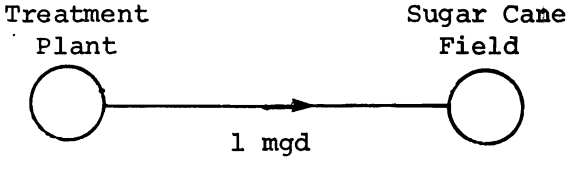
a. Analysis

The economic feasibility of using effluent for irrigation is analyzed by comparing the following two options.

Option 1



Option 2



(continued on page 191)

Option 1 represents the case in which 1 mgd of wastewater is not reused but has to be discharged in an injection well. In addition, 1 mgd of water from the most expensive source (i.e., that source for which exchange with wastewater is most desirable) is transported to the sugar cane fields. Option 2 represents the case in which wastewater is reused by transporting 1 mgd of wastewater to the sugar cane field, while water supply source remains available for other uses.

Results of this comparison are presented in the following table where it is assumed that (1) reuse by Pioneer Mill results in less basal groundwater used in Lahaina; (2) reuse of Wailuku wastewater by HC&S results in less basal groundwater used in Wailuku; and (3) reuse of Kihei wastewater by HC&S results in less water pumped from Big Spring in the ditch system. Estimates for the capital and energy cost of injection wells were obtained from the wastewater team and of water supply system from table on page 149.

Cost Difference With and Without Wastewater Reuse

	Lahaina	Wailuku	Kihei
Without Reuse			
Cost of Groundwater			
Capital		150	158
Energy	285	288	457
Wastewater Disposal			
Capital	300	300	300
Energy	100	100	100
Total	685	838	915
With Reuse			
Capital	190	190	230
Energy	117	117	177
Total	307	307	407

b. Conclusion

From the above analysis it is clear that wastewater reuse for irrigation is desirable from an economic efficiency perspective.

4. NED c

NED c, accounting for the interface with wastewater, is presented on page 110. The plan uses effluent from the wastewater treatment plant in Lahaina for Pioneer Mill's irrigation needs, and in Wailuku and Kihei for HC&S. As a result of this use, pumping of basal groundwater at Lahaina and Central Maui is reduced.

5. Short-Term Decisions

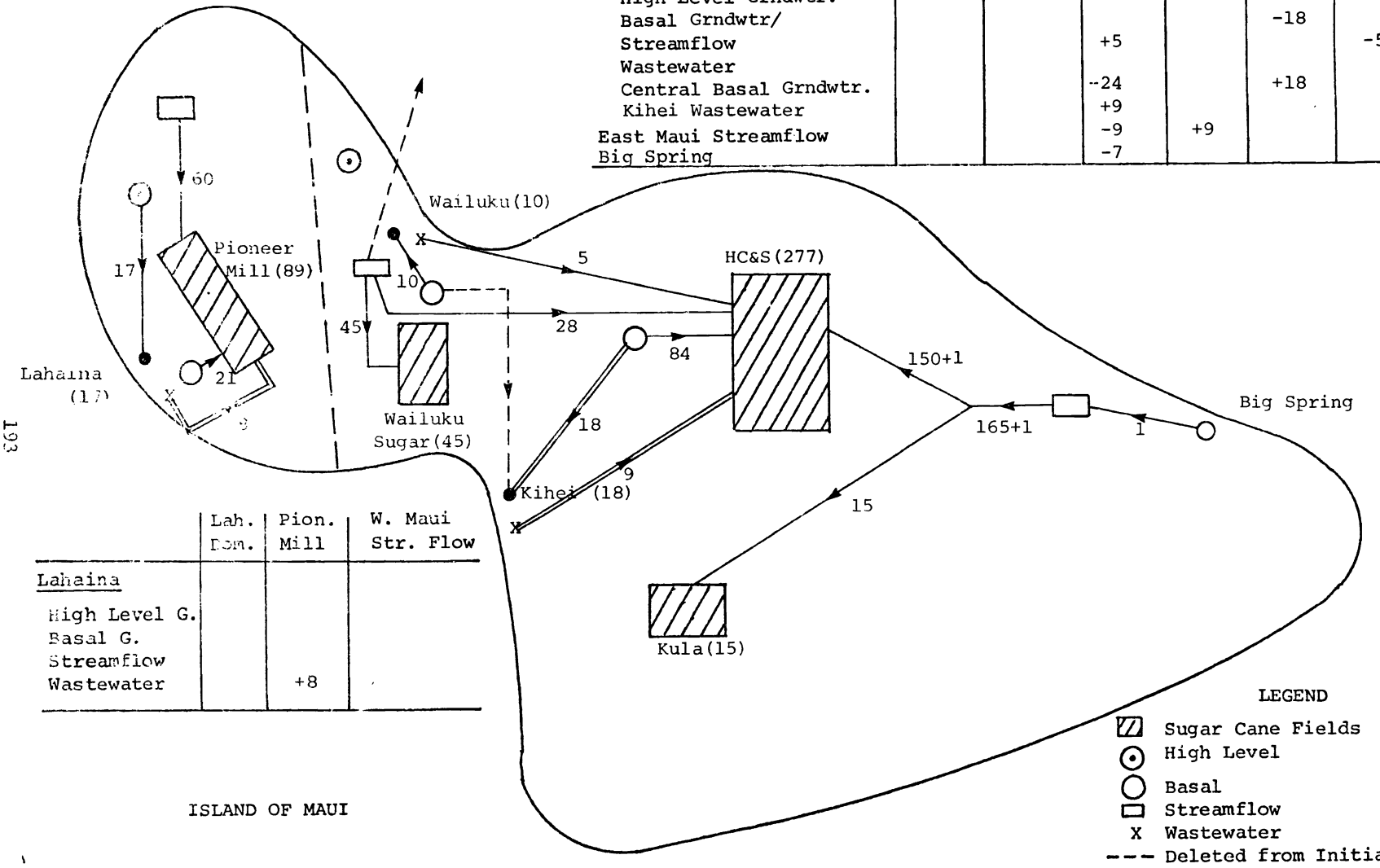
Decisions associated with NED c are the same as for the NED Plan, and, in addition:

> Investigate the feasibility of wastewater reuse in terms of its quality aspects for sugar cane irrigation.

MODIFICATIONS OF FIRST-CUT NED PLAN: NED c, Comments

1. Compare the NED c plan with the plan on page 211.

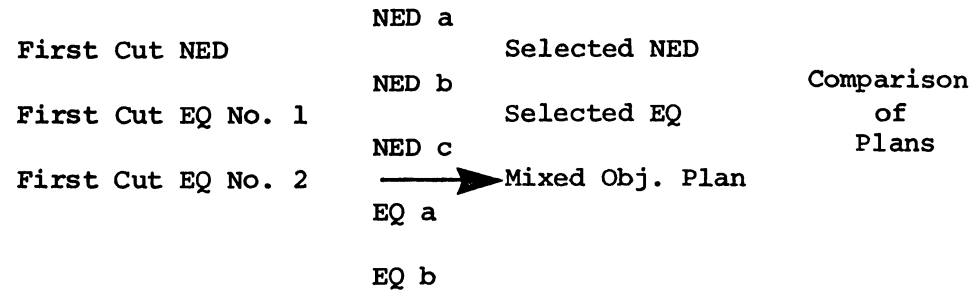
	Wailuku					E. Maui Stream-flow
	Dom.	Sugar	HC&S	Kula	Kihei	
Wailuku						
High Level Grndwtr.						
Basal Grndwtr/					-18	
Streamflow			+5			-5
Wastewater						
Central Basal Grndwtr.			-24		+18	
Kihei Wastewater			+9			
East Maui Streamflow			-9	+9		
Big Spring			-7			



	Lah. Dom.	Pion. Mill	W. Maui Str. Flow
Lahaina			
High Level G.			
Basal G.			
Streamflow			
Wastewater		+8	

NED C: Deviations from Initial Plan

PHASE 3



MIXED OBJECTIVE PLAN: Emphasis on capturing the full range of plan impacts by selecting a plan in between the selected NED and the EQ plans (Section IV, pages 66 and 67).

1. Some of the characteristics of each of these two extreme plans will be deleted in order to arrive at one or more plans that gives weight to both NED and EQ and as such presents one possible compromise between the two. The purpose is not to arrive at the recommended plan at this stage. This perspective is important because it makes the exact compromise between NED and EQ less crucial; also the mixed objective plan is not considered the culimination point of all plan formulation efforts. Instead it simply represents another plan designed to more fully represent the range of possible impacts associated with long-term water supply plans on Maui.

2. The differences between the mixed objective plan and the initial plan are summarized in the foldout on page 211.

MIXED OBJECTIVE PLAN: Considerations

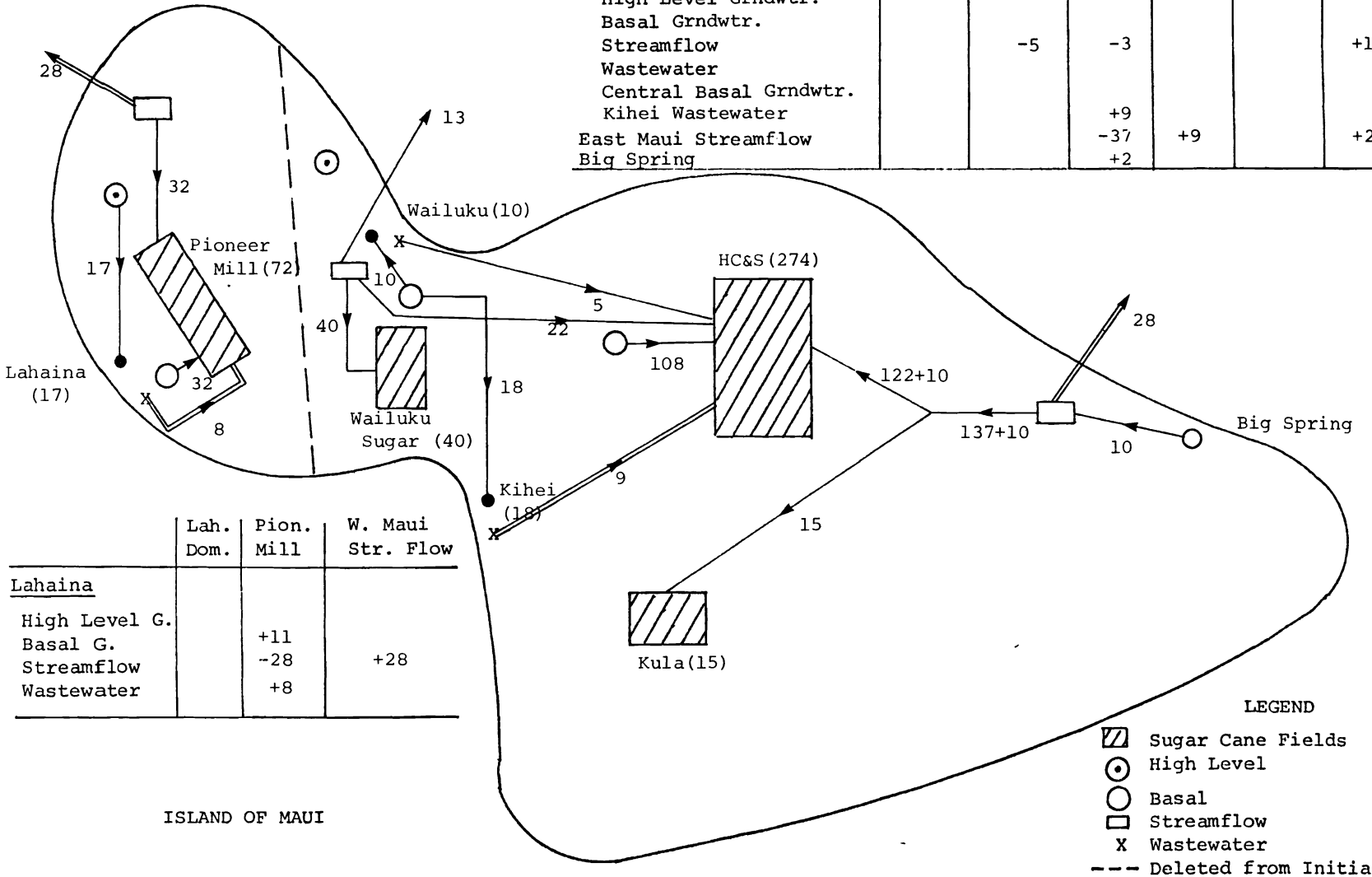
Basis for Mixed Objective Plan

- Wastewater reuse in EQ plan is a desirable feature and is retained in mixed objective plan.
- Instream flow requirements for Lahaina differ substantially between the two plans; to develop alternative options in between these two it is assumed for the mixed objective plan that half of the remaining requirements for Pioneer Mill are supplied by basal groundwater and the other half by streamflow diversions. This results in instream use of 28 mgd.
- In the mixed objective plan no sugar cane field expansion is assumed in order to allow for instream use of water in East Maui streams. New available acreage is generally at higher elevations and the only economically feasible supply source would be high level streamflows. As a result with sugar cane field expansion no water would be available for instream use.
- Pioneer Mill and Wailuku Sugar are assumed completely converted to drip irrigation. For HC&S however the 13,000 acres in furrow according to the initial plan are not converted to drip. This eliminates additional pumping needs otherwise required to use the savings from the conversion to drip.
- Kihei is served by basal groundwater at Wailuku, since Central Maui's basal groundwater is needed by HC&S without conversion of 13,000 acres to drip.
- Kula demand is assumed at 15 mgd and is served as in the NED plan by East Maui streamflows.
- Big Spring is used to supplement water in the ditch at higher elevations for irrigation by HC&S.
- The remaining requirements are satisfied by Wailuku and East Maui streamflows in such a way that for each the same percentage of available supply is diverted.

Short-Term Decisions

- Start development of high level groundwater in Lahaina.
- Investigate feasibility of wastewater use for sugar cane irrigation.
- Decide on size of diversions for different streams.
- Decide on pipeline from Wailuku basal groundwater to Kihei.
- Decide on development of Big Spring.

	Wailuku					E. Maui Stream-flow
	Dom.	Sugar	HC&S	Kula	Kihei	
Wailuku						
High Level Grndwtr.						
Basal Grndwtr.						
Streamflow		-5	-3			+13
Wastewater						
Central Basal Grndwtr.						
Kihei Wastewater			+9			
East Maui Streamflow			-37	+9		+28
Big Spring			+2			



	Lah. Dom.	Pion. Mill	W. Maui Str. Flow
Lahaina			
High Level G.			
Basal G.		+11	
Streamflow		-28	+28
Wastewater		+8	

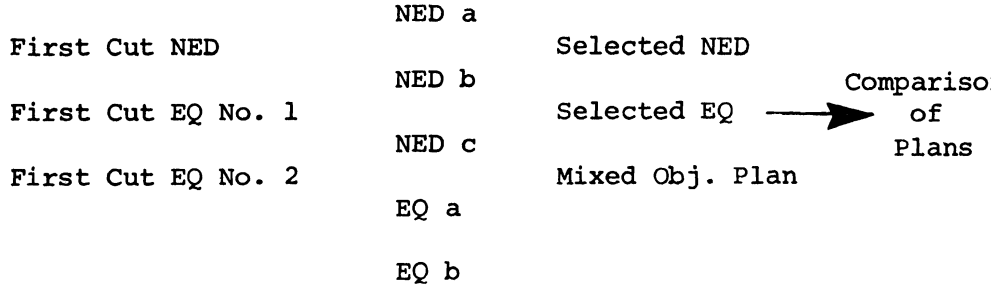
ISLAND OF MAUI

LEGEND

- Sugar Cane Fields
- High Level
- Basal
- Streamflow
- X Wastewater
- Deleted from Initial
- Same as Initial
- Added to Initial
- 84 mgd Transported
- (15) mgd Demanded

MIXED OBJECTIVE PLAN: Deviations from Initial Plan

PHASE 3



COMPARISON OF PLANS: Emphasis is on comparing the selected plans using the system of accounts from the P&S (Section IV, pages 67 through 69).

1. Five plans are compared: (1) Initial Plan; (2) NED Plan; (3) EQ Plan; (4) NED c and (5) Mixed Objective Plan. First, the impacts associated with the plans are identified in general terms, and then the list of effects in the P&S is checked in order to identify the effects to be measured. Finally, the identified impacts are translated into effects and displayed in the system of four accounts: NED, EQ, RD and SWB.

2. In line with the water supply plan formulation orientation (i.e., development of year-2000 plans to be used in surfacing the most critical short-term decisions associated with various plans), the effects displayed are primarily intended to serve as a guide for short-term decision making (i.e., when to begin development of high level groundwater, which streamflows to divert, etc.). Thus the display provides an indication of what may be expected if the decisions recommended in Phase 4 are biased towards a particular plan. This thrust is in contrast to displaying effects for the purpose of selecting "the" water supply plan for the year 2000.

3. Impacts displayed on the opposite page were identified for the purpose of the case study. It is noted that in an actual planning situation input from the public is essential in selecting the impacts to be presented since these impacts provide the means for linking concerns of local people with the plans developed in the study. The display of effects in the system of accounts, presented on page 203, and based on the impacts identified, has a slightly different connotation. Its purpose is to display consequences of plans from a national perspective. For example, the NED account identifies the value to the nation of different resource allocations while the RD account is used to identify possible shifts among regions (i.e., Maui as well as other regions in the nation) as a result of different resource allocations provided in the plans.

(continued on page 200)

COMPARISON OF PLANS: Impact Identification

Impacts \ Plans	Initial Plan	NED Plan	EQ Plan	NED c Interface With Wastewater	Mixed Objective
(1) Domestic Demand (mgd)	45.0	45.0	45.0	45.0	45.0
(2) Truck Farming (acres, Kula)	4,400	15,400	4,400	15,400	15,400
(3) Sugar (total acres)	48,600	48,600	45,000	48,600	45,000
- drip irrigation	28,600	41,600	45,000	41,600	32,000
- furrow irrigation	20,000	7,000	0	7,000	13,000
(4) Sugar Production (tons/year)	327,350	343,600	326,250	343,600	310,000
(5) Total Streamflow used (mgd)	293	298	191	298	229
- low flow	5(2%)	0	107(36%)	0	69(23%)
(6) Groundwater Used (mgd)	182	168	198	151	195
(7) Wastewater Used (mgd)	5	5	22	22	22
(8) Total Cost of Water Supply, Drip Irrigation and Effluent Disposal (million $)	74.7	74.2	83.7	65.6	81.2
(9) Capital Costs (million $)	19.6	14.4	22.0	16.5	23.6
(10) Energy Costs (Present Value - million $)	34.0	32.2	39.2	28.3	41.6
(11) Drip Irrigation Costs (million $)	14.3	20.8	22.5	20.8	16.0
(12) Cost of Wastewater Disposal (million $)	6.8	6.8	0	0	0
(13) O&M Costs	O&M cost is assumed the same for all plans				

4. The purpose of the P&S checklist is to identify what effects can be measured based on the effects presented on page Effects cannot be mesured in all P&S categories because the Level B plans may not allow for identification or measurement of effects in these categories. Similarly, not all effects listed on page 203 are reflected in the effects listed in the P&S.

(continued on page 202)

COMPARISON OF PLANS: P&S List of Effects

NED Account

P&S	Plans
Beneficial	
A. Value of increased output of goods and services	✓
B. Value of output resulting from external economics	
Adverse	
A. Value of resources required for a plan	✓
B. Losses in output from external diseconomies	

EQ Account

P&S	Plans
Beneficial	
A. Open, green space, wild, scenic rivers, lakes, beaches, shores, mountain wilderness area, estuaries, other areas of beauty	✓ (green space & beaches)
B. Archeological, historical, biological, geological resources and selected ecosystems	✓ (biological & ecosystems)
C. Quality of water land and air resources	✓ (water, air)
D. Irreversible committments of resources to future	✓

RD Account

P&S	Plans
1. Regional income	✓
2. Regional employment	
3. Population distribution	✓
4. Regional/economic base and stability	✓
5. Environmental considerations of special concern to region	

SWB Account

P&S	Plans
1. Effect on real income	✓
2. Effect on security of life, health, and safety	
3. Effects on educational, cultural, recreational opportunities	
4. Effects on emergency preparedness	
5. Other	

5. Initially the value of increased output of goods from truck farming was included under the NED account. However, analysis in the RD account showed that this increase is balanced by a decrease in output of truck farm products in California. As a result the increase in truck farming production in Maui is to be deleted from the NED account.

COMPARISON OF PLANS:
NED Account

Effects \ Plans	Initial Plan	NED Plan	EQ Plan	NED c Interface With Wastewater	Mixed Objective Plan
Beneficial					
A. Value of increased output of goods and services					
(1) Sugar Production per year (million $)	58.9	61.8	58.7	61.8	55.8
(2) Truck Farm Production (million $)	2.2	7.7	2.2	7.7	7.7
Adverse					
A. Value of Resources Used					
(3) Total Water Supply System Costs (millions)	74.7	74.2	83.7	65.6	81.2
(4) Capital Costs (million $)	19.6	14.4	22.0	16.5	23.6
(5) Energy Costs (Present value million $)	34.0	32.2	39.2	28.3	41.6
(6) Drip Irrigation Costs (million $)	14.3	20.8	22.5	20.8	16.0
(7) Cost of Wastewater Disposal	6.8	6.8	0	0	0
(8) O&M (million $)	same	same	same	same	same

See Comments, page 104

ASSUMPTIONS

(1) Based on price of sugar (1973) @ $180/ton.

(2) Based on national average productivity and value for the 17 principal truck farm products on Kula in their respective proportions (@ $500/acre).

(3) Total of capital costs + energy costs + drip irrigation costs + wastewater.

(4) Includes source development, pipeline and treatment.

(5) Based on $.03/kwh present value.

(6) Based on $500/acre.

(7) Based on input provided the WQ and WWM team.

(8) O&M cost is assumed the same for different water supply system and irrigation methods.

COMPARISON OF PLANS:
EQ Account

Effects \ Plans	Initial Plan	NED Plan	EQ Plan	NED c Interface with Wastewater	Mixed Objectiv Plan
(1) Green Space (% of cultivated green acres)	76%	76%	70%	76%	70%
(2) Biological	Habitat of fish population in Maui streams (gobies,prawns, shrimp,limpets) is eliminated by streamflow use	Habitat of fish population in Maui streams (gobies,prawns, shrimp,limpets) is eliminated by streamflow use	Maintains fish habitat	Habitat of fish population in Maui streams (gobies,prawns, shrimp, limpets) is eliminated by streamflow use	Maintains fish habitat
(3) Ecological	Exotic ecosystems are introduced with dry streams	Exotic ecosystems are introduced with dry streams	--	Exotic ecosystems are introduced with dry streams	--
(4) Water Quality	Perennial streams (Kahakuloui, Iho, Honopou, Kapaula) dry during part of the year	Perennial streams dry (same)	--	Perennial streams dry (same)	--
	No groundwater recharge on 59% of sugar acreage	No groundwater on 86% of sugar acreage	No groundwater recharge on 100% of sugar acreage (decreases WQ) potential salinity increase	No groundwater recharge on 86% of sugar acreage	No groun water re charge c 71% acre

COMPARISON OF PLANS:
RD Account

Effects \ Plans	Initial Plan	NED Plan	EQ Plan	NED c Interface with Wastewater	Mixed Objective Plan
(1) Regional Income					
Increase in sugar production	21%	27%	21%	27%	15%
	No redistribution effects in other principal regions*)				
Increase in truck farm acreage.	238%	1,084%	238%	1,084%	1,084%
	Redistribution of truck farm production in California.**)				
(2) Economic Base/ Stability	With the above increases in truck farming, more diversity occurs in the economy, as additional income/employment opportunities other than sugar and tourism are made available.				

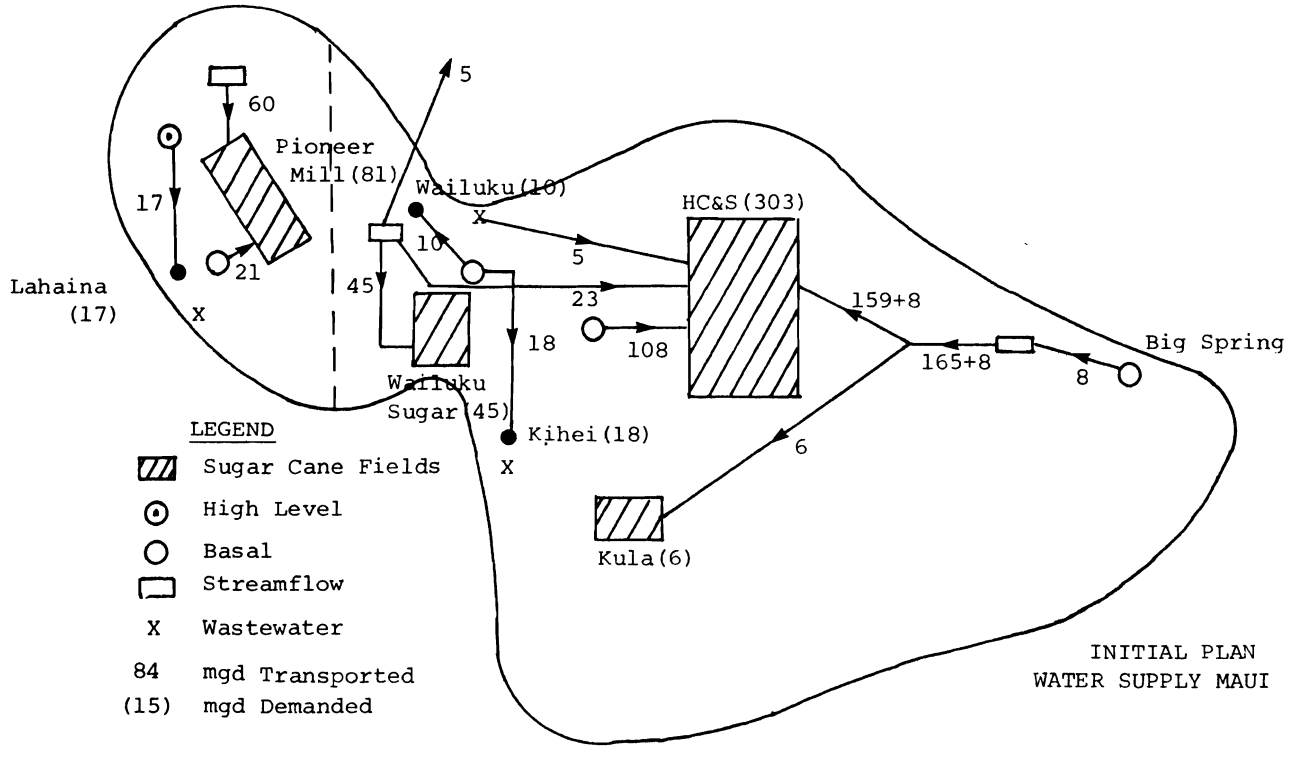
*) Hawaii produces 40 percent of sugar cane in the United States. The other principal region (60 percent) is the Florida and Louisiana area. Since the United States is a net importer of sugar cane, the percent increase in sugar production on Maui should not result in any adverse effect on production in Florida and Louisiana. Therefore an addition to regional income occurs on Maui without reduction elsewhere in the nation.

**) Since Hawaii imports vegetables and other truck farm products, principally from California, a redistribution effect takes place. With increased production on Maui, less vegetables will need to be imported from California, where production will decrease.

COMPARISON OF PLANS:
SWB Account

Plans Effects	Initial Plan	Ned Plan	EQ Plan	NED c Interface With Wastewater	Mixed Objective Plan
(1) Effects on Real Income	Increases in truck farming productivity result in an opportunity for increased income/standard of living for existing truck farmers. It also provides additional employment/income opportunities other than sugar and tourism.				

Supply/Demand Connections	Initial Plan (in mgd)	Changes from Initial Plan (in mgd) NED Plan	EQ Plan	NED c Interface with Wastewater	Mixed Objective Plan
Lahaina					
High Level - Lah. Dom.	17				
Basal - Pion. Mill	21	+8	+24		+11
Streams- Pion. Mill	60		-41		-28
Instream Use (F&W)	--		+41		+28
Wastewater - Pion. Mill	--		+8	+8	+8
Wailuku					
Basal - Wail. Dom.	10				
Basal - Wail. Sugar	--				
Basal - Kihei	18	-18		-18	
Streams - Wail. Sugar	45		-10		-5
Streams - HC&S	23	+5	-5	+5	-3
Instream Use (F&W)	5	-5	+15	-5	+13
Wastewater - HC&S	5				
Central Basal - HC&S	108	-24		-24	
Central Basal - Kihei	--	+18		+18	
Wastewater Kihei - HC&S	--		+9	+9	+9
East Maui					
Streams - HC&S	159	-9	-46	-9	-37
Streams - Kula	6	+9		+9	+9
Streams - Kihei	--				
Instream Use (F&W)	--		+46		+28
Big Spring - HC&S	8	+2	-8	-7	+2
Total Water Demand	485	-14	23	-14	35



PHASE 4: ANALYSIS OF TRADEOFFS AND SELECTION OF A RECOMMENDED PLAN

The purpose of Phase 4 as interpreted for the Maui case study is to (1) summarize and screen the short term decisions surfaced in Phase 3; (2) analyze and present implications of short term decisions to the public for their response; (3) summarize the public response to the issues presented; (4) develop a comprehensive set of study recommendations; (5) develop recommendations in terms of required action, agency involvement, and costs; (6) present a summary of Level B study. Key outputs in this phase are:

→ Summary of Short Term Decisions

Initial Presentation of Short Term Decisions

Public Response on Initial Presentation

Study Team Recommendations

Program Synthesis

Summary Level B Study

SUMMARY OF SHORT TERM DECISIONS: provides starting point for Phase 4 by summarizing and screening the short term decisions that were identified for the plans selected in Phase 3.

1. In the context of Level B water supply planning on Maui, Phase 4 is oriented towards resolving the short term decisions - identified in Phase 3 and necessary to implement each of the selected plans. The short term recommended water supply plan for Maui subsequently is composed of the sum of the individual recommendations for each of these decisions. As a result the orientation of the planning effort in Phase 4 is distinctly different from Phase 3. Where in Phase 3 it is primarily the task of the planner to cover the spectrum of possible plans and to identify key decisions, in Phase 4 the emphasis shifts to resolving key decisions associated with water supply planning. The important implications are: (1) the recommended plan is not necessarily one of the plans developed in Phase 3 (limiting the choice to those plans only may preclude some alternatives more responsive to public needs) and (2) emphasis shifts to relating information on key decisions to the public. As a result format and content may differ from that used in Phase 3, i.e., a decision's implication is presented in terms understandable to the public and not necessarily in the format of the NED and EQ account in the P&S.

2. In order to organize the work in Phase 4, the first task performed

(continued on page 214)

SUMMARY OF SHORT TERM DECISIONS ASSOCIATED WITH THE PLANS SELECTED IN PHASE 3

	Short Term Decisions	Perceptions of Study Team: Non Controversial	Highly Controversial	Depending On Resolution of Highly Controversial Decisions
1.	Develop high level groundwater for Lahaina domestic.	X		
2.	Investigate feasibility of wastewater reuse for sugar cane irrigation.	X		
3.	Investigate effects of drip irrigation on change in groundwater infiltration and recovery as well as irrigation needs and sugar production.	X		
4.	Use of wastewater for sugar cane irrigation.			X
5.	Extent of diversion of streamflows for irrigation purposes and their identification.[1)]		X	
6.	Increase in demand for Kula for truck farming.		X	
7.	Source of supply for Kihei resort development from basal groundwater in Central Maui or Wailuku, or East Maui streamflows.		X	
8.	Extent of converting sugar cane irrigation from furrow to drip irrigation.			X
9.	Expansion of sugar cane fields over present acreage.			X
10.	Development of additional basal groundwater for Wailuku domestic.			X
11.	Development of Big Spring to augment flow in irrigation ditch.			X
12.	Follow-on work needed for focuses 1,3,4 and 6 not selected for Level B study.			X

1) This decision results from work performed in establishing minimum streamflow requirements on Maui, an interface for which responsibility was assigned to the fish and wildlife team.

by the study team is to summarize and screen the total set of decisions. Screening is oriented towards identification of the type of analysis that the team will have to perform in order to arrive at resolutions. As indicated in the table on page 213, the study team perceives that some decisions are essentially noncontroversial since they were included in each of the plans. The only thing to be done is to formulate a recommendation. Other decisions were perceived as highly controversial and the study team has to analyze and present to various publics the implications of alternative choices in order to make an informed decision based on public response. Finally, a set of decisions is identified for which resolution has to wait until it is known how the highly controversial decisions are resolved.

PHASE 4

Summary of Short Term Decisions

→ Initial Presentation of Short Term Decisions

Public Response on Initial Presentation

Study Team Recommendations

Program Synthesis

Summary Level B Study

INITIAL PRESENTATION OF SHORT TERM DECISIONS: Provides the first response from the study team to the public on how to resolve the short term decisions.

1. The information for this output, displayed on the next pages represents the content of what the study team anticipates to present to the public. The format in which this information is presented to the public can take many different forms. As such the displayed output is an internal document to prepare the team for an effective public meeting.

2. The presentation is organized following the types of short term decisions presented in the summary. Thus, the study team formulates first recommendations on the noncontroversial decisions; i.e., decisions No. 1,2 and 3 of page 2213. In addition the study team presents the recommendations on those highly controversial interface decisions that were assigned to other teams. In this case the recommendation on minimum streamflow requirements, prepared by the fish and wildlife team, is presented and used to resolve the decision on the extent of streamflow diversions; i.e., decision No. 5 on page 213. Second, the study team presents its analysis of the implications associated with the remaining highly controversial decisions without recommending resolution; i.e., decisions No. 6 and 7 on page 213. The initial presentation does not cover decisions No. 4, 8, 9, 10, 11 and 12 since their resolution is dependent on how the highly controversial ones are resolved.

3. The public meeting in which the initial presentation is made is characterized by specific exchanges between study teams and public. The study team needs to thoroughly prepare this meeting in order to obtain the necessary feedback that will allow for making informed decisions. As a result the timing of this meeting is not immediately after the start of Phase 4, but after the study team has analyzed each of the decisions listed in the

(continued on page 218)

I. Recommendations on Noncontroversial Short Term Decisions Prepared by Water Supply Team

For the short term decisions without apparent conflict the study team will present the following recommendations to the public.

Decision No. 1. High Level Groundwater for Lahaina. Start development of high level groundwater sources in West Maui for serving domestic use in Lahaina area.

Decision No. 2. Investigation of Wastewater Reuse. Investigate the feasibility of wastewater reuse for sugar cane irrigation starting in 1980 taking into account sugar cane quality, environmental quality, and implementation problems.

Decision No. 3. Investigation of Drip Irrigation. Develop improved estimates by 1980 of the effects of drip irrigation on change in groundwater infiltration and recovery as well as irrigation needs and associated sugar cane production per acre.

(continued on page 219)

summary. This meeting can either be held for each functional area separately or for all functional areas together. The basic criterion for the study manager in selecting a format for the meeting as well as in selecting the publics to be addressed is the ability to use this public exchange as an effective mechanism for arriving at sound recommendations.

4. Interaction of teams, such as between the water supply and fish and wildlife team, on an interface selected for further study is necessary during the entire study. Thus, even though the fish and wildlife team has responsibility for the decision on minimum streamflow requirements, the water supply team is expected to understand and have reached agreement with the fish and wildlife team on the recommendations. As such it should be able to present the water supply aspects of the recommendations to the public although it may refer to the fish and wildlife team for details on the fish and wildlife aspects.

5. The recommendation on minimum streamflow requirements is based on a set of artificial assumptions with respect to fish and wildlife since the fish and wildlife aspects of such a requirement were not addressed in the case study.

(continued on page 220 .

II. Recommendations on Highly Controversial Interface Decisions Prepared by Other Teams

Minimum Streamflow Requirements as Recommended by the Fish and Wildlife Team (related to Decision No. 5)

Recommendations: The recommendations of the fish and wildlife team on the minimum streamflow requirements for the various streams on Maui are specific with respect to individual streams and their needs. These recommendations were translated by the fish and wildlife team into aggregate requirements as needed by the water supply team. The result was:

	Aggregate Minimum Streamflow Recommended (in mgd)
East Maui	28
Lahaina	20
Wailuku	16

Summary of Basic Reasons for Recommendations and Implications for Stream-Flow Diversions

East Maui: The fish and wildlife team determined that based solely on fish and wildlife consideration minimum streamflow requirements aggregated for East Maui would be equivalent to an annual average of 50 mgd. One of the key implications of satisfying such requirements is that sugar cane fields at higher elevations most likely would have to be reduced because the use of alternative water supply sources instead of the streamflows would require large pumping cost. After the fish and wildlife team presented this information to the public and based on their response, the team made the decision that the public cost of reducing sugar cane acreage is larger than that of reducing the aggregate minimum streamflow below 50 mgd. On the other hand the public benefit of further expanding sugar cane acreage, which would take place at higher elevations and could only be served by streamflows, was judged less than the cost of the required further reduction in minimum streamflows. Based on the above reasoning the fish and wildlife team recommended that in arriving at minimum streamflow requirements the water supply demand of the existing sugar cane fields at higher elevations, while using drip irrigation, would be considered as a constraint. In addition, satisfying the projected 2000 year demand in Kula was considered a constraint. The existing

(continued on page 221)

6. It is noted that in the process of developing a recommendation for minimum streamflow, resolution of other short term decisions may be required first.

(continued on page 222)

demand for sugar cane irrigation, which presently depletes the East Maui streamflows is 165 mgd and can be reduced by drip irrigation to 132 mgd, while the projected demand for Kula is 15 mgd. Assuming the development of 10 mgd at Big Spring the resulting minimum streamflow requirement that can be attained is 28 mgd, which subsequently was recommended by the fish and wildlife team.

Lahaina: Aggregated over W. Maui fish and wildlife requirements are equivalent to an annual average of 20 mgd. It was recommended by the fish and wilflife team to satisfy these requirements. It is noted that no major conflicts with the water supply system would results.

Wailuku: For the Wailuku area the recommended requirements were based on the following reasoning. The total demand for HC&S based on existing fields with 18,000 acres in drip irrigation is 274 mgd of which 132 mgd are satisfied by East Maui streamflows and Big Spring. The remaining demand of HC&S at lower elevations of 142 mgd can be satisfied using Central Basil (108 mgd), wastewater reuse (14 mgd) and Wailuku streamflows (20 mgd). As a result the minimum streamflow would be 8 mgd, which satisfies only part of the requirements for fish and wildlife. Increasing this would require either additional use of drip irrigation at lower elevations, or development of additional basal groundwater, or reduction of sugar cane fields. The last two alternatives were not judged desirable by the fish and wildlife team, as compared to marginal improvement in fish and wildlife. However, it is feasible to convert 5,000 acres to drip irrigation and reduce the use of Wailuku streamflows. The savings in irrigation needs of 10 mgd and a reduction in groundwater of 2 mgd result in the recommended minimum requirements equivalent to 16 mgd annual average.

Note: The following preliminary recommendations were made relevant to the Short Term Decisions 4,8 and 9 on page 213.

Decision 4: Use wastewater from Wailuku and Kihei to irrigate HC&S sugar cane fields.

Decision 8: Convert an additional 5,000 acres of HC&S sugar cane fields at lower elevation to drip irrigation.

Decision 9: The acreage of sugar cane fields at higher elevations on East Maui should not be expanded.

Decision 11: Develop Big Spring up to 10 mgd in order to irrigate HC&S sugar cane fields.

7. Where Section I of the initial presentation contains recommendations that may be modified based on public response, Section II presents no recommendations on how the decisions are to be resolved. Instead it presents for the highly controversial decisions the implications of alternative choices. In other words, it provides insight into what one "loses" versus what one "gains" if decisions are resolved in a particular way, i.e., the tradeoffs. The concept of tradeoffs is applied to the implications of decisions and actions which can be presented to and valued by different groups. Tradeoffs are analyzed for each highly controversial decision as contrasted to trading off between complete plans. In summary, tradeoff analysis entails analyzing the implications of key decisions and obtaining value information from different groups which subsequently can be taken into account once the study team makes its recommendations.

(continued on page 224)

III. Highly Controversial Short Term Decisions

The implications of alternative choices for two decisions are presented:

Decision No. 6: Increase in demand for Kula for truck farming.

Decision No. 7: Source of supply for Kihei resort development from basal groundwater in Central Maui or Wailuku, or East Maui streamflow.

A. Kula Demand

Implications associated with alternative levels of water supply provided to Kula are directly related to alternative growth rates for truck farming and its associated implications. Thus a decision to increase the water supply to Kula requires that a choice is made between alternative rates of growth for truck farming. The latter depends on desired economic structure, in particular balance between sugar cane and truck farming.

To gain insight into the implications of increasing the demand the following will be presented:

- Employment implications of alternative growth rates for truck farming.
- An exploratory calculation for a particular level of water supply demand.
- Complementary programs to increase the demand.
- Advantages and disadvantages of increasing growth rates.
- Study team's perception of key concerns and key public groups to be addressed.

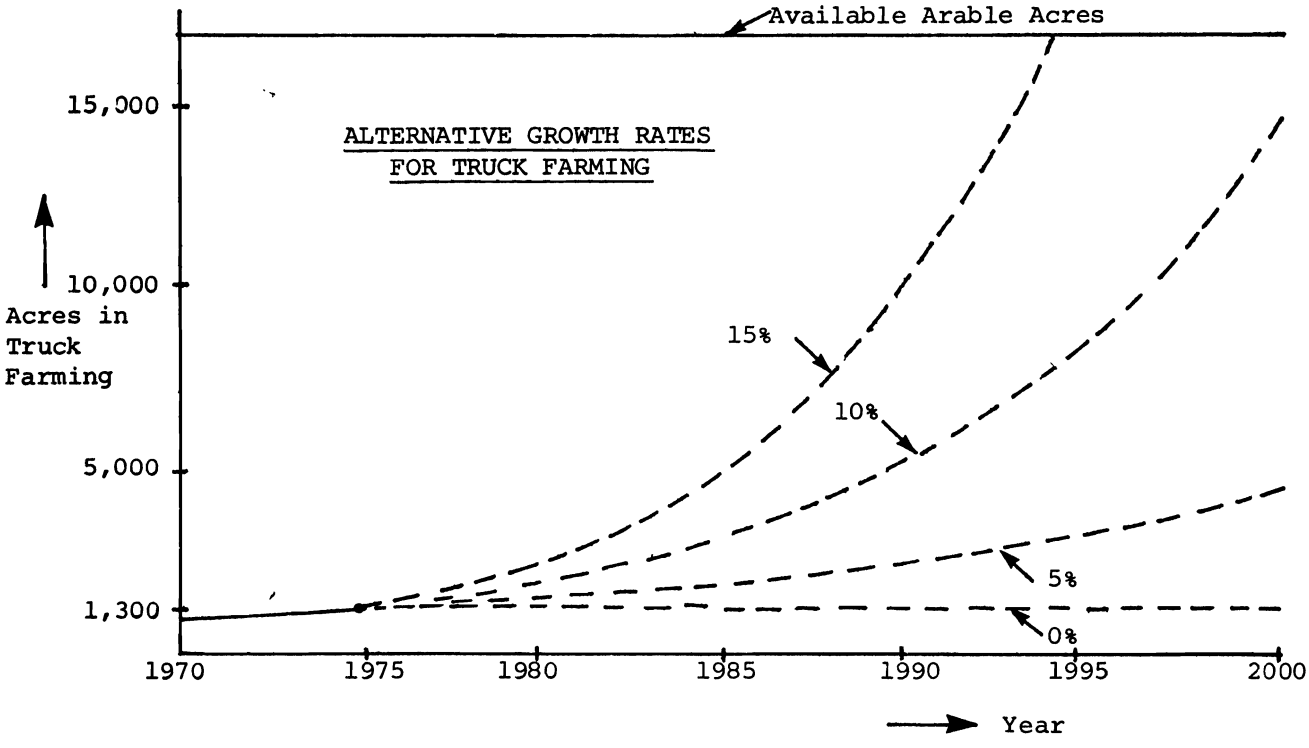
1. Employment Implications

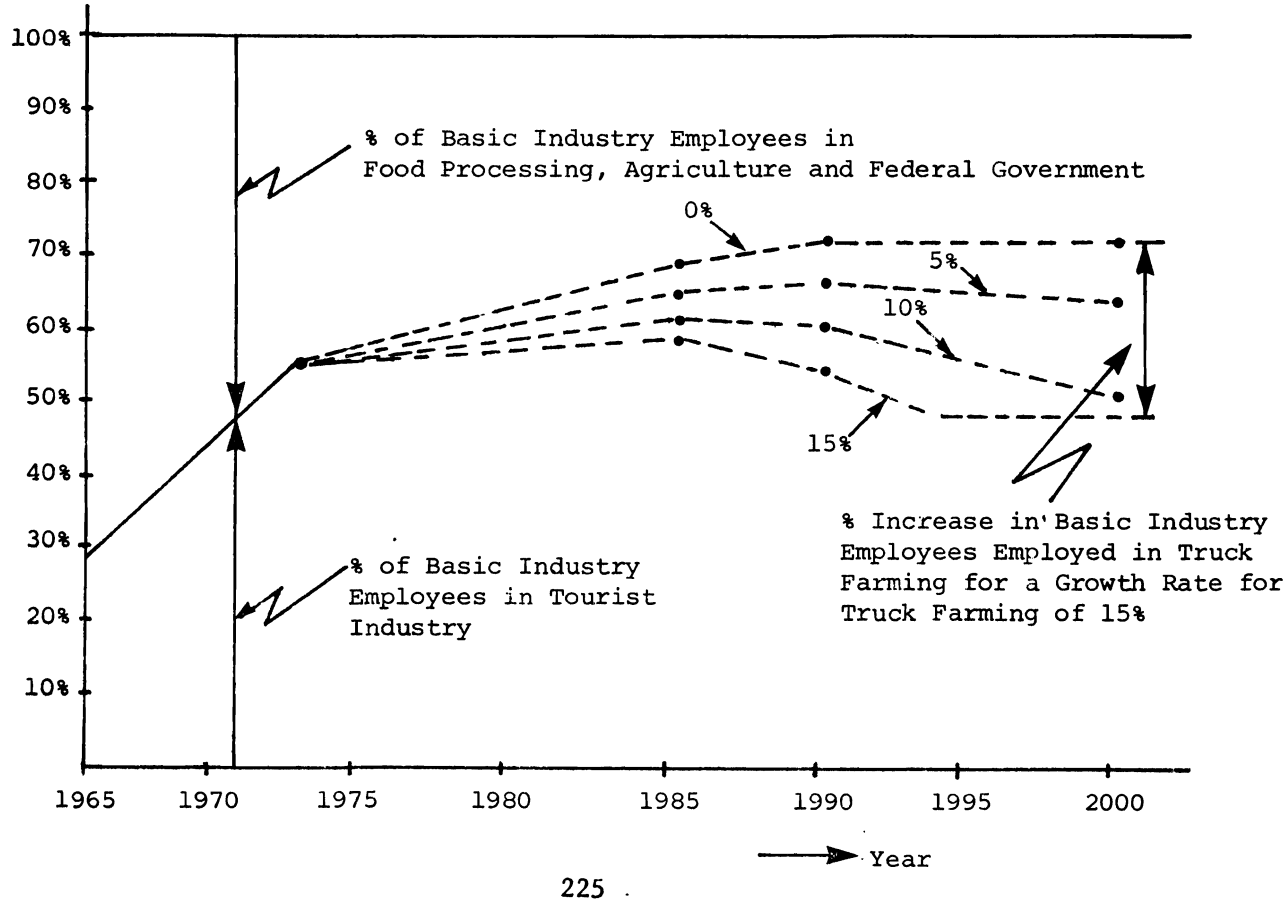
Figures on the following page indicate alternative growth rates for truck farming and the employment structure on Maui for each of the alternative growth rates.

The projected employment structure is based on the assumption that (1) 42 employees in truck farming are added for every 100 acres, (2) these employees are in addition to those projected for Maui in the State's Economic Base Study, and (3) trends projected in Economic Base Study represent 0% increase in truck farming.

8. The growth and employment analysis provides an opportunity for the water supply team to interact on a substantive basis with the economic base study performed by the State by analyzing the implications of an increased growth rate from a water supply perspective. This is especially important since increasing the growth rate is counter to State policy but in line with County policy. Thus the Level B Study provides a mechanism to contribute towards resolution of the truck farming problem by clearly stating the alternatives from a water supply perspective.

(continued on page 226)


Available Arable Acres
15,000
ALTERNATIVE GROWTH RATES
FOR TRUCK FARMING
10,000
Acres in
Truck
Farming
15%
10%
5,000
5%
1,300
0%
1970
1975
1980
1985
1990
1995
2000
Year


100%
90%
80%
% of Basic Industry Employees in
Food Processing, Agriculture and Federal Government
70%
0%
5%
60%
10%
50%
15%
40%
30%
% Increase in Basic Industry
Employees Employed in Truck
Farming for a Growth Rate for
Truck Farming of 15%
% of Basic Industry
Employees in Tourist
Industry
20%
10%
1965
1970
1975
1980
1985
1990
1995
2000
Year

9. The exploratory calculation is designed to show in clear terms the implications of a number of feasible choices on a comparable basis, so that the public can relate to it. On Maui, truck farming of 2,000 acres is a feasible choice if provisions are also made to increase productivity so as to make truck farming a profitable operation. Increasing sugar cane acreage is another feasible option. Furthermore, it is noted that a set of indicators is used which is expected to be of interest to the public because they relate to concerns expressed.

(continued on page 228)

2. Exploratory Calculations: Comparison of 2 mgd for Either 2000 Acres Truck Farming or 250 Acres Sugar Cane

	Truck Farming	Sugar Cane
Total Irrigation Requirements in mgd	2	2
Irrigation Requirements per Acre in Gallons Per Day	1,000[1)]	8,000[2)]
Acres	2,000	250
Annual Production in $/Acre	500[3)]	1,305[4)]
Total Annual Production in $	1,000,000	326,250
Employment Per 100 Acres	42[5)]	5[6)]
Total Employment	840	125
Estimated Profit in %	0[7)]	20 [8)]

Notes:

1) High estimate based on water requirements for lands suitable for crop farming by DOWALD and on including residential water needs.

2) Based on the use of drip irrigation on additional sugar fields.

3) Based on national average productivity and value for the 17 principal truck farm products on Maui in their respective proportions.

4) Based on productivity of 7.25 tons of sugar per year @ $180/ton.

5) Based on total employment in other agriculture on Maui of 550 and the agricultural acreage in Kula of 1,300 in 1972.

6) Based on total employment in sugar of 2,273 and total acreage of 45,677 for Maui in 1970.

7) No estimate of profit in truck farming available but given comments on its marginal nature it is assumed close to 0%.

8) Based on $30 profit out of $180 sale per ton of sugar.

(continued on page 229)

10. In the identification of complementary programs there is an opportunity for the water supply team to interact with other Level B study teams on a substantive basis. With respect to increasing truck farming, the feasibility of improved transportation of products to markets is a case in point, where the interaction with the navigation study team may lead to more specific recommendations. It is noted that at this point in the planning process the required specificity of the implications allows for interaction to be substantive and focused.

11. Major concerns to be addressed and key public groups to be contacted are identified explicitly so as to assure that public responses needed by the study team to arrive at a recommendation are obtained. It is emphasized that the study team is interested in orienting the public meetings toward major concerns and key public groups that will help in resolving the decisions that confront study managers and study teams. Since the Level B study in Hawaii is a State and Federal effort, the only other key publics for the water supply team are local groups on Maui.

3. Complementary Programs to Increase Truck Farming

The following programs are needed to support increase in truck farming on Maui:

- Program to improve efficiency of truck farming such as through assistance from Department of Agriculture's Extension Service.
- Program to make economic size lots available to farmers either through leasing or purchasing.
- Program to improve transportation to markets such as Honolulu.

4. Advantages/Disadvantages of Higher Growth Rate

Advantages

- Improved balance between tourist industry and other basic industries, especially with respect to available employment opportunities.
- Larger increase in value of production and in employment as compared to growth in sugar industry.
- Less dependent on the mainland, i.e., with high growth rates for truck farming economy is less dependent on tourism from the mainland and on farm products from California.
- Increasing truck farming is responsive to desires by local residents to own and operate their own business instead of having to rely on employment in sugar or tourist industry.

Disadvantages

- Profitability of truck farming is marginal at the present time although it may be improved in the future.
- A higher growth rate would require special programs to improve truck farming's competitive situation.

5. Study Team's Perception Regarding Concerns and Public Groups to be Addressed in Public Meeting

Concerns to be addressed: (1) Value of production, (2) Employment, (3) Profitability, (4) Economic Structure, (5) Cost to Public.

Public groups to be contacted: (1) Truck Farmers, (2) Sugar Industries, (3) County, (4) General Public.

B. Supply Source for Kihei

Based on the results of Phase 3 a choice is needed among three possible sources of water supply for Kihei: Wailuku Basal, Central Basal and East Maui Streamflows.

1. Overview of Alternative Sources

Sources	Present Value of Incremental Cost for Kihei		Other Present/ Future Uses
	Capital	Energy	
New Wailuku Basal	630	377	None
Existing Central Basal	320	194	Presently by HC&S; reduction could be achieved with drip irrigation making water available for Kihei.
Existing Maui Streamflows	700	28	Presently by HC&S; future needs for in-stream use and for truck farming in Kula.

2. Comparison of Sources

	New Wailuku Basal	Existing Central Basal	East Maui Streamflows
Advantages	. Local planning for project is completed. . Water is available for immediate use in Kihei resort development.	. Cheapest alternative	. Cheaper than New Wailuku Basal.
Disadvantages	. Most expensive alternative.	. Water is not available until drip irrigation is installed at lower elevations by HC&S. . Savings from drip irrigation are uncertain.	. Streamflow needed to satisfy needs for instream use. . Streamflow needed to satisfy increased irrigation demand in Kula.

3. Concerns Related to Alternative Sources

Concerns to be addressed: (1) Cost, (2) Availability.

Public groups to be contacted: (1) Resort Developers Kihei, (2) General Public, (3) County.

PHASE 4

Summary of Short Term Decisions

Initial Presentation of Short Term Decisions

→ Public Response on Initial Presentation

Study Team Recommendations

Program Synthesis

Summary Level B Study

PUBLIC RESPONSE ON INITIAL PRESENTATION: Documents the response of the various public groups addressed by the study team in public meetings.

1. Public response is organized in a similar manner as the initial presentation. However the response received from each key public group is not confined to major concerns identified by the team before the meeting. First, the responses are more difficult to classify by major concerns because the relationship is not one to one and not always in terms used by the planner. Second, during the meeting significant issues may arise that have to be included in this output. However the team's identification of major concerns beforehand is necessary to orient the discussion during the public meeting and as such is crucial.

2. The content of the public response displayed on the opposite pages is artificial in the sense that no actual presentation on short term decisions was made in the course of the case study. It represents to a large extent the response anticipated given the comments received in the course of the study effort.

3. Documentation of public response to initial presentation is needed so that decision makers and reviewers can follow the arguments leading to the study recommendations.

(continued on page 234)

I. Recommendations on Noncontroversial Decisions Prepared by Water Supply Team

Public response to presentation of the recommendations on high level groundwater development, wastewater reuse investigation and drip irrigation investigation was not in opposition to the study team's thinking. No unanticipated problems surfaced as a result of presentation.

II. Recommendation on Minimum Streamflow Requirements Prepared by Fish and and Wildlife Team

The public response to this recommendation is documented in the report by the fish and wildlife team. The implications mentioned for water supply will be incorporated in the water supply plan.

III. Highly Controversial Short Term Decisions

Public response to the implications of short term decisions on Kula demand and Kihei source development was extensive and is summarized below.

A. Demand Projection for Kula

Truck Farmers

- Continuation of past trends of low growth will result in truck farming remaing a marginal operation.
- Programs are needed for truck farmers to help them compete for available resources in Maui against large sugar industries and resort developers.
- Truck farmers have always been last in line for water although situation is improving with recent agreements after disastrous 72-73 droughts.
- Not all truck farmers are happy with 15% growth rate because it takes time to expand markets; most would prefer a growth rate around 10% in the short term, and possibly higher in the future.

Sugar Industries

- Water can be used more profitably to grow sugar instead of growing crops for truck farming, i.e., sugar cane profit about 20% and truck farming close to zero.
- A high growth rate for truck farming can only be achieved if that part of the economy is subsidized through various programs.
- Artificial stimulation of a high growth rate is at the cost of sugar cane.
- A 5% growth rate is considered reasonable given the conflicting interests.

(continued on page 235)

3. The expression of environmental concern by the general public is a typical example of an important issue that surfaces during the public meetings and which received less emphasis in the team's initial presentation. Because of its controversial nature, study manager and study team will have to take it explicitly into consideration in arriving at a recommendation for increasing the demand in Kula.

County of Maui

- The county supports high growth of around 10% for truck farming, in particular because of employment opportunities generated.
- The county has proposed a 500 acre agricultural park to facilitate acquisition of land by farmers in economic size lots together with programs for efficient cooperative use of farm equipment.
- Markets for products from truck farming are expected to develop more easily once interisland transportation by boat is improved.
- The need to interface with transportation studies was stressed.

General Public

- The general public is worried about economic stability and outside interests on the island since without additional truck farming it appears that by 2000 72% of future basic industry employees is in the tourist industry. Preference is for a more balanced economic structure.
- Population should not be forced to work in tourist industry; alternatives such as agriculture should be available and with declining employment opportunities in sugar cane,truck farming needs to be stimulated.
- Major environmental concern is related to the impact higher growth rates will have on island's population. Thus if truck farming is projected at 10% and if there is no reduction in other basic industries such as sugar and tourism, then 13,000 acres in truck farming will add about 5,500 employees or 22,000 people to Maui's population of 63,000 projected for year 2000. Before deciding on continued 10% growth rate for truck farming the population level should be determined so that the environment can be maintained at an acceptable level.
- Stimulation of truck farming should not result in increased taxes to citizens
- A 10% growth rate is considered a reasonable and acceptable level to aim for.

(continued on page 237)

B. Source of Water Supply for Kihei

Resort Developers, Kihei

- Assured availability of water is absolutely necessary for a successful resort development in Kihei area which cannot count on savings from drip irrigation to supply needed demand.

- Developers have spent much time and effort developing the Wailuku alternative for this reason.

General Public

- The general public goes along with the use of Wailuku groundwater, but it was pointed out that earlier anticipation of the needs could have allowed for better interface between installation of drip irrigation for sugar cane and Kihei resort development.

- Flexibility in the design of the transmission line was emphasized so that for instance,central basal groundwater could still be used for Kihei if savings from drip irrigation turn out to be substantial.

County

- The county is in basic agreement with the Wailuku source development for Kihei.

STUDY TEAM RECOMMENDATIONS: Comments

PEASE 4

Listing and Screening of Short-Term Decisions

Initial Presentation of Short Term Decisions

Public Response on Initial Presentation

Study Team Recommendations

Program Synthesis

Summary Level B Study

STUDY TEAM RECOMMENDATIONS are guided by public response. This output represents the study team's recommendations on how to resolve the short-term decisions.

1. This is the culmination point of Phase 4. After the team (1) summarizes the decision to be addressed; (2) presents recommendations on noncontroversial decisions and implications of controversial decisions to the public; and (3) receives and documents public response; then the team makes up its mind on how to resolve each short-term decision. The sum total of all recommendations on short-term decisions constitutes the essential input for formulating the recommended 1985 water supply plan for Maui. Once the team has formulated this plan, recommendations for the focuses that were not selected in the Level B study are formulated.

2. The recommendations made by the study team in the initial presentation could change as the result of public response. In this case, however, public response was in agreement with initial recommendations so no change was made.

3. Because of public response, flexibility in design was added to one of the alternatives for satisfying the demand in Kihei. Thus, none of the three alternatives presented by the study team was chosen in its original form, but instead a modification of one of the alternatives was selected.

(continued on page 242)

STUDY TEAM RECOMMENDATIONS

I. Recommendations on Noncontroversial Decisions Prepared by Water Supply Team

- Develop high level groundwater on West Maui for domestic use in Lahaina area.
- Investigate wastewater reuse for sugar cane irrigation.
- Investigate effects of drip irrigation on infiltration, recovery, irrigation needs and productivity.

II. Recommendations on Highly Controversial Short Term Decisions

A. Demand Projection for Kula

Plan for 10% growth in truck farming acreage through 1985 and design water supply system such that by 1985 an additional 4 mgd can be supplied to Kula for irrigation purposes.

Complementary Program: Develop comprehensive program for truck farming in Kula including methods for improved efficiency, for making agricultural land available to farmers, and for transporting goods to markets.

Considerations

- Truck farming produces a higher value of products for the same amount of water as sugar cane (NED).
- Local desire for better balance between tourist industry and other basic industries (RD).
- Given the scarcity of water and the fact that with same amount of water sugar cane can support considerably less employees, truck farming expansion is chosen over sugar cane expansion (RD and SWB).
- The less profitable condition of truck farming at the present requires a special program to improve conditions (implementation).

(continued on page 241)

B. Source of Water Supply for Kihei

Use basal groundwater from Wailuku to satisfy demand in Kihei. In addition provide flexibility in the design of the system so that possible savings from drip irrigation at lower elevations can be used to satisfy part of future Kihei demand. The developed groundwater sources in Wailuku will then be used to satisfy its increased domestic needs.

Considerations

- Savings from drip irrigation from East Maui streamflows are not available because they are needed for instream use and for Kula demand.
- Savings from drip irrigation from central basal groundwater are not available in the short run and their long term availability is uncertain.
- Local commitment has been made to Wailuku basal groundwater as source for Kihei.
- Flexibility included because pumping cost of central basal groundwater is substantially less than of Wailuku basal, while the initial cost of including flexibility is small.

4. After the study team has resolved the controversial decisions, recommendations on the remaining decisions whose resolution is dependent on the former group can be resolved. Thus recommendations for decisions No. 4,8,9,10,11 and 12 on page 213 can be prepared.

(continued on page 246)

III. Recommendations on Remaining Short Term Decisions

The remaining short term decisions relate to completing the recommended 1985 water supply plan for Maui. First, the demands for the 1985 plan are summarized based on information generated in Phase 3 and based on resolution of decisions presented to the public. Second, recommendations for the remaining decisions are formulated in terms of their implications for the 1985 plan.

A. Projected Demand for 1985

Irrigation requirements are based on the following recommendations with respect to the short term decisions 8 and 9 (page 213):

(1) Expansion of drip irrigation is based on the expected acreage remaining in furrow (page 33), except for HC&S where an additional 5,000 acres is converted to drip based on the recommendation made by the fish and wildlife team.

(2) Sugar cane acreage remains at the present level, based on the recommendation made by the fish and wildlife team that sugar cane acreage at higher elevations on East Maui should not be expanded and based on the absence of suitable land at other locations.

	Present	1985
Lahaina Domestic[1)]	3	9
Pioneer Mill[2)]	102	81
Wailuku Domestic[1)]	4	8
Wailuku Sugar[2)]	50	45
HC&S[2)]	305	264
Kula[3)]	1.6	6
Kihei[1)]	2	9

1) Based on interpolation of demand for the year 1985 in Maui Master Plan Report; Lahaina and Kihei include demands for resort areas.

2) Irrigation requirements are derived from the following application rates and acreages for the year 1985.

Irrigation Method	Application in Gallons/Acre/Day	Pioneer Mill Acres	Wailuku Sugar Acres	HC&S Acres
Furrow	10,000	4,500	2,500	8,000
Drip	8,000	4,500	2,500	23,000

3) Based on 10% growth rate for truck farming acreage.

(continued on page 245)

B. Remaining Short Term Decisions

The remaining short term decisions relate to the basic design of the water supply system in 1985 and include resolution of decisions 4, 10 and 11 (page 213).

Lahaina Domestic: Use existing source of 2 mgd basal groundwater, obtain 7 mgd from new high level groundwater source, and eliminate use of streamflow for domestic use.

Pioneer Mill: Use allowable 40 mgd from streamflows, 4 mgd from wastewater and 37 mgd from existing basal groundwater sources. If economically desirable, use residual 5 mgd of existing basal groundwater sources and develop new basal sources for more intensive irrigation of sugar fields.

Wailuku Domestic: Use existing source of 4 mgd basal groundwater and obtain another 4 mgd from new basal groundwater sources.

Wailuku Sugar: Use 45 mgd required for irrigation from Wailuku streamflows.

HC&S: Use 133 mgd available from East Maui streamflows after subtracting demand for instream use and for Kula; use 10 mgd available from Wailuku streamflows after subtracting instream use and use Wailuku Sugar; use 4 mgd wastewater from Wailuku and Kihei each; use all 106 mgd central basal groundwater; supply residual demand of 7 mgd with Big Spring water.

Kula: Continue use of 2 mgd existing streamflow supply and satisfy 4 mgd increase with East Maui streamflow.

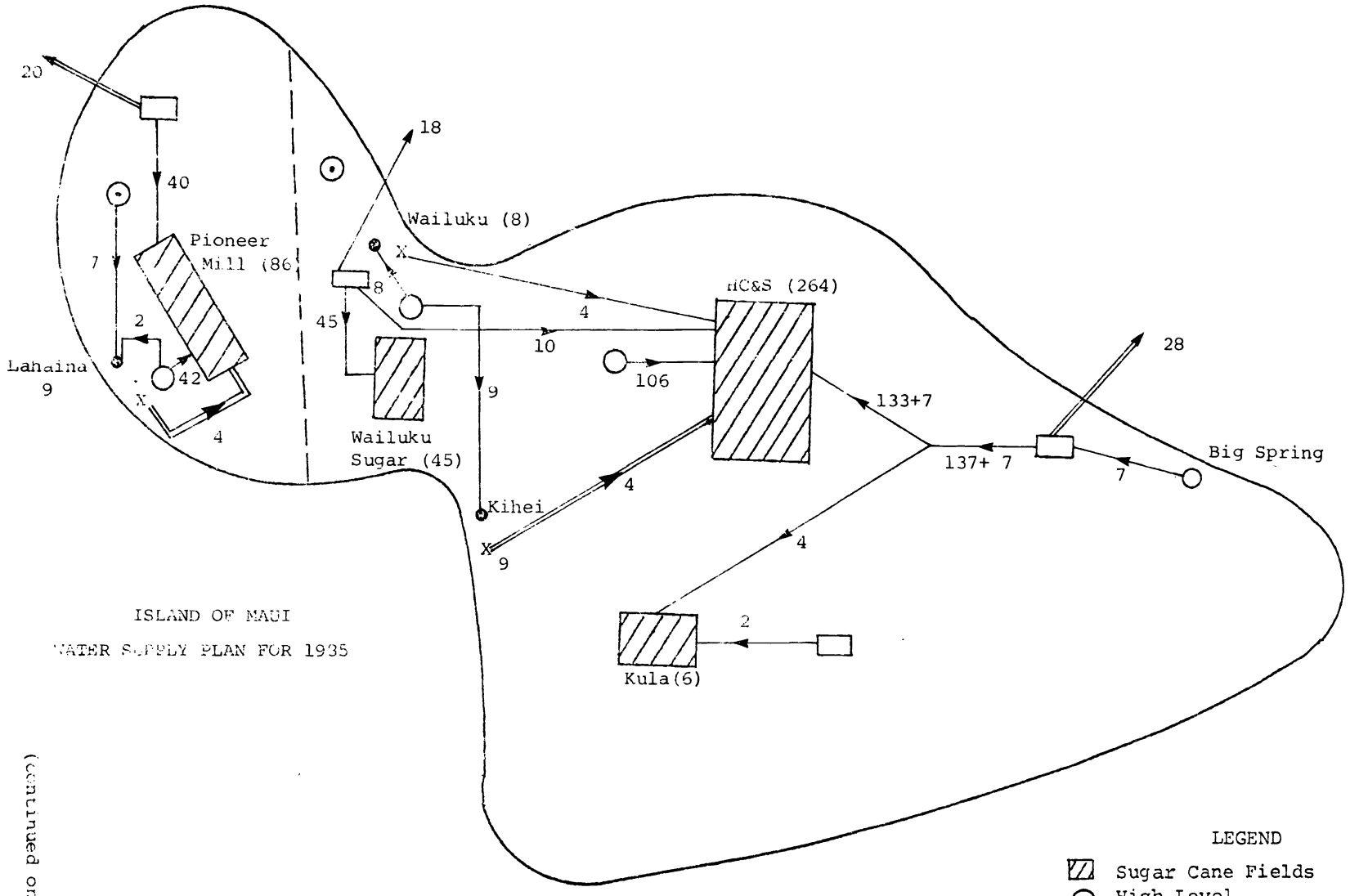
Kihei: Add 7 mgd to present source of 2 mgd from Wailuku basal groundwater.

IV. 1985 System Plan

The recommended 1985 water supply plan is presented in terms of a system diagram depicting the connections between demand centers and supply sources. In addition, recommendations regarding specific timing for system development are presented on page 166 in terms of the initiation time and rate of development of supply sources to serve Lahaina domestic, Pioneer Mill and HC&S.

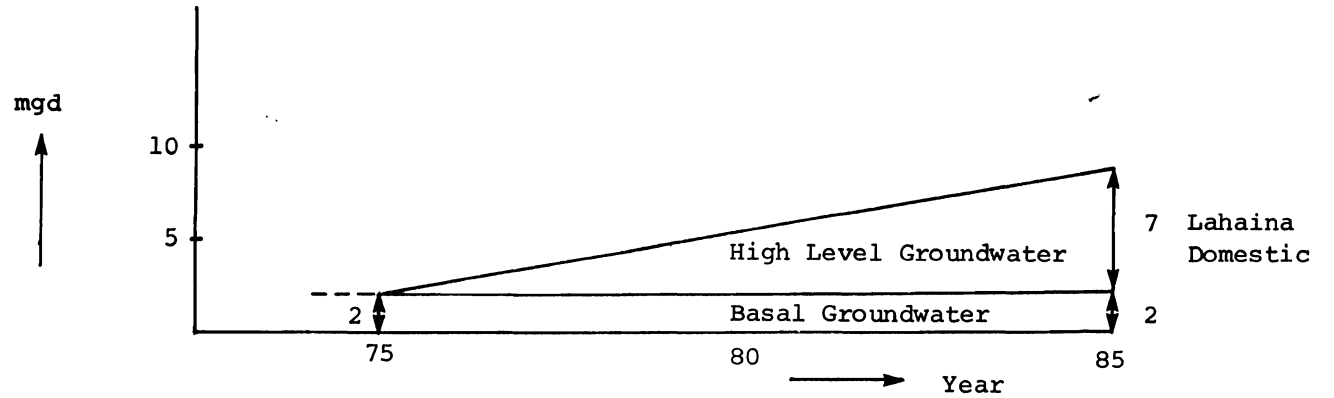
(continued on page 247)

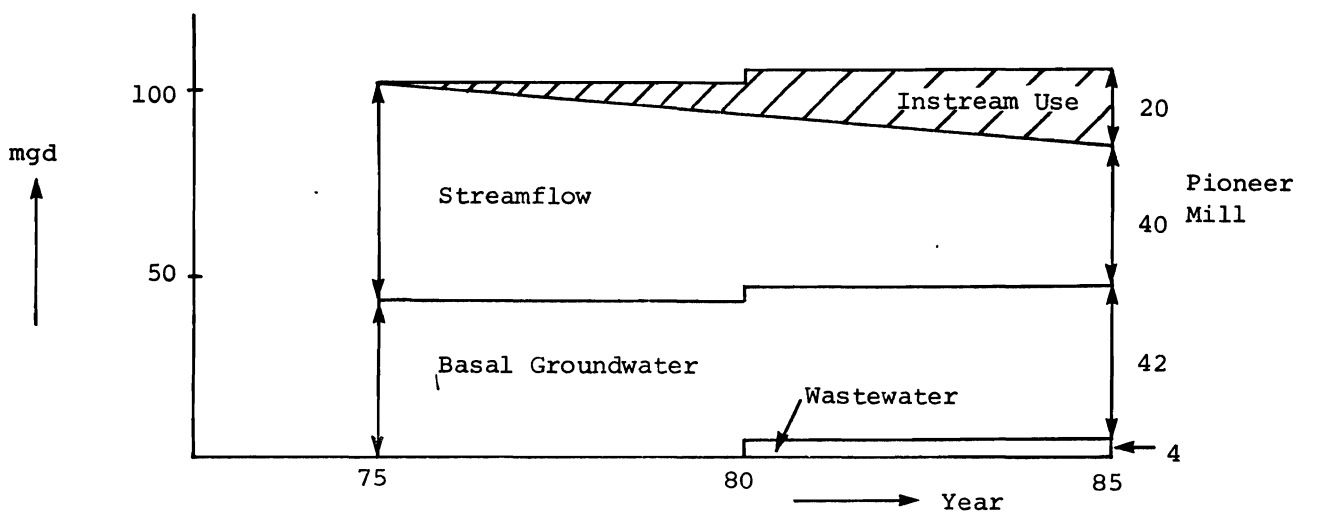
5. Compare Water Supply Plan for 1985 to the plan on page 211.

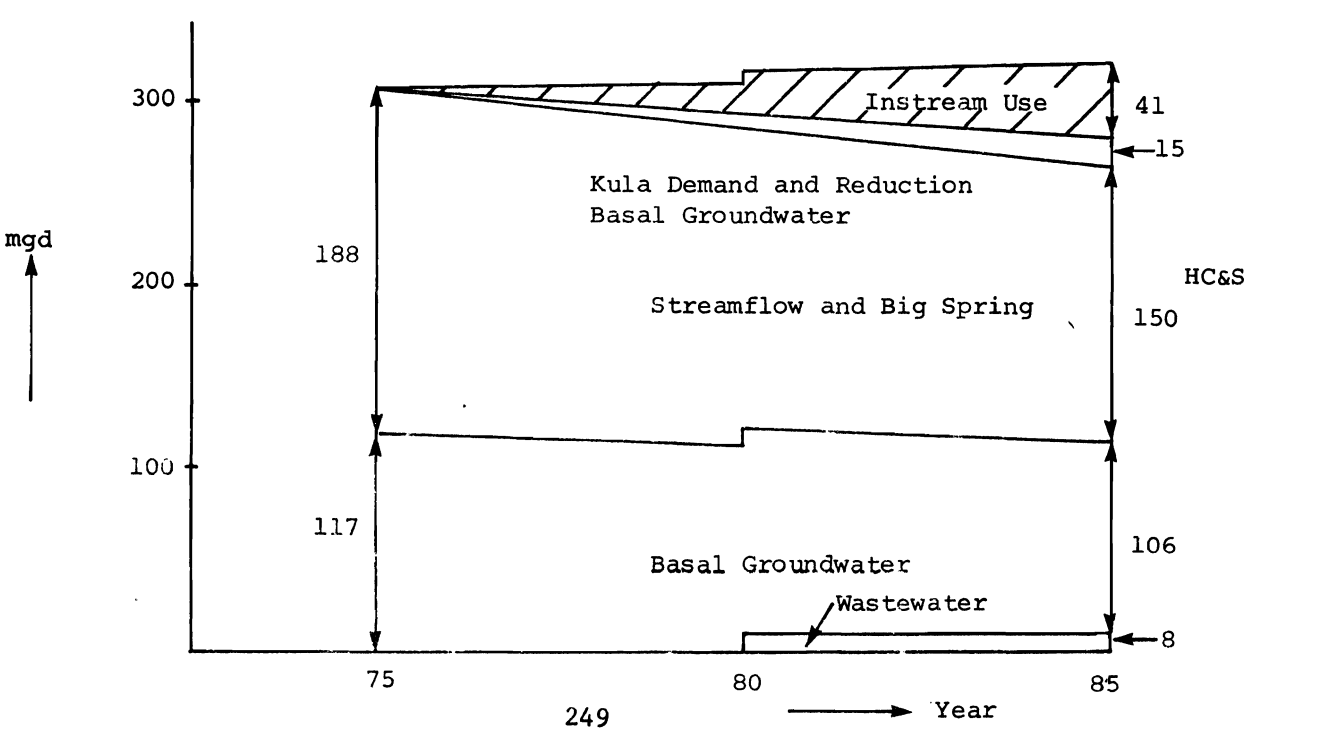


(continued on page 249)

STUDY TEAM RECOMMENDATIONS: Timing of System Development







5. The nonselected focuses listed on the opposite page were identified in Information Display No. 2 of Phase 1. A decision to not pursue these focuses in the Level B study was made at the end of Phase 1. Based on the insight gained in the course of the study and on the recommendations made so far, a recommendation for each of the nonselected focuses is needed. Recommendations may range from specific Level C studies to special investigations.

V. Recommendations on Nonselected Focuses

Demand Estimation, Focus 1. New comprehensive demand projections should be made in 1980, when additional information on drip irrigation is available and actions presented in this Level B study should have been implemented.

Supply Measurement, Focus 3. Prepare brief report on possible implications of Hanapepe Decision on water supply on Maui. No large scale effort is desirable until final decision in court case has been reached.

Demand/Supply Comparison, Focus 4. Develop Plan of Study for investigating feasibility of storing water between seasons by recharging of the groundwater. At the present not enough information is available to decide on the level and type of investigation needed.

Institutional Arrangements, Focus 6. Based on the plans recommended investigate possible arrangements between public and private parties involved in the development of the water supply system.

PHASE 4

Summary of Short Term Decisions

Initial Presentation of Short Term Decisions

Public Response on Initial Presentation

Study Team Recommendations

→ Program Synthesis

Summary Level B Study

PROGRAM SYNTHESIS: This output is a translation of the recommended water supply plan into an administrative program specifying the actions and roles of various participants in the implementation of the plan.

1. Program synthesis starts with a summary of the decisions recommended by the study team, categorized in terms that are convenient for program development. For example all decisions related to source development per se are grouped together. Subsequently, direct and complementary actions associated with the decisions are identified. Following this identification is an estimation of the total cost associated with the actions and, thus, with the plan. Finally the cost is allocated between NED and EQ. NED costs are allocated to specific functional areas and a cost sharing arrangement among the various participants implementing the plan is projected.

(continued on page 254

PROGRAM SYNTHESIS: Recommended Decisions

Category	Recommended Decision
1. System Development (Source and Transmission)	1. Develop 7 mgd high level groundwater in Lahaina.
	2. Wastewater reuse for Pioneer Mill: 4 mgd from Lahaina.
	3. Develop 11 mgd basal groundwater at Wailuku for Wailuku domestic (4 mgd) and Kihei (7 mgd).
	4. Wastewater reuse for HC&S: 4 mgd from Wailuku and 4 mgd from Kihei.
	5. Develop Big Spring: 7 mgd.
	6. Reduce pumping from Central Basal by 11 mgd.
	7. Deliver 4 mgd to Kula.
	8. Deliver 9 mgd to Kihei.
2. Drip Irrigation	1. Drip irrigation for Pioneer Mill on 4,500 acres.
	2. Drip irrigation for Wailuku Sugar on 2,500 acres.
	3. Drip irrigation for HC&S on 23,000 acres.
3. Investigations	1. Investigate feasibility of wastewater reuse for sugar cane irrigation.
	2. Investigate effects of drip irrigation.
4. Resolutions	1. Resolve to limit minimum streamflows on Lahaina, Wailuku and East Maui streams to an equivalent aggregate annual averages of 20, 18 and 28 mgd, respectively.

2. Each recommended decision has a series of accompanying direct actions which are needed to implement the decision. These actions should be identified as part of the program for the short term plan.

(continued on page 258)

PROGRAM SYNTHESIS: Direct Actions

Recommended Decision	Direct Actions - System Development: Exploration Program	Design Study	Construction of Wells and/or Pipelines	Discontinued Practice
Develop 7 mgd high level groundwater in Lahaina	X	X	X	
Wastewater reuse for Pioneer Mill: 4 mgd from Lahaina	*)	X	X	
Develop 11 mgd basal groundwater at Wailuku: Wailuku domestic (4 mgd) and Kihei (7 mgd)	X	X	X	
Wastewater reuse for HC&S: 4 mgd from Wailuku and 4 mgd from Kihei	*)	X	X	
Develop Big Spring: 7 mgd		X	X	
Reduce pumping from Central Basal by 11 mgd				X
Deliver 4 mgd to Kula			X	
Deliver 9 mgd to Kihei			X	

*)See investigation on feasibility of wastewater reuse for irrigation purposes

Recommended Decision	Direct Actions - Drip Irrigation: Purchase Irrigation System	Installation of Irrigation System
Drip irrigation for Pioneer Mill on 4500 acres	X	X
Drip irrigation for Wailuku Sugar on 2500 acres	X	X
Drip irrigation for HC&S on 18,000 acres	X	X

(continued on page 257)

PROGRAM SYNTHESIS: Direct Actions (cont.)

Recommended Decision	Direct Actions - Investigation	
	Study Plan	Research
Investigate feasibility of wastewater reuse for sugar cane irrigation	X	X
Investigate effects of drip irrigation	X	X

Recommended Decision	Direct Actions - Resolution
Resolve to limit minimum streamflow on Lahaina, Wailuku and East Maui streams to an equivalent aggregate annual acreage of 20, 18 and 28 mgd	Specify State regulations to set limits where the legal form depends on the final outcome of the Hanapepe Decision

3. The decision to develop high level groundwater in the Lahaina area cannot be fully implemented unless access rights are obtained for exploration, source development and drilling purposes. Likewise an agricultural program by USDA to assist truck farmers in Kula is another example where complementary action is needed. Because of the potential scope of complementary actions and associated difficulties in estimating the cost, these actions are identified but their costs are not included in subsequent analysis.

PROGRAM SYNTHESIS: Complementary Actions (Examples)

Recommended Decision	Complementary Actions
1. Develop 7 mgd high level groundwater in Lahaina.	1. Obtain necessary access rights for exploration and source development - drilling and installation (County of Maui).
2. Deliver 4 mgd to Kula for truck farming.	1. Agricultural extension program to increase efficiency of truck farmers (USDA).
	2. Economic lot sizing and acquisition program (County Agricultural Program and USDA).
	3. Program to improve transportation of farm products to markets (State Dept. of Transprotation.
3. Wastewater reuse for Pioneer Mill.	1. Changes in public health law allowing use of wastewater for irrigation (State Legislature).

4. Total cost is first allocated to the NED and EQ objectives. Resulting NED costs are allocated to study purposes, or alternatively, among functional areas. In this respect it is noted that according to the P&S (page 140) only NED costs can be allocated among functional areas. Consequently the EQ cost is not further allocated and it is assumed that the Federal government will bear the EQ cost.

5. The criterion used to separate the costs of the investigations on drip irrigation and the irrigation system necessary to achieve minimum streamflow requirements between NED and EQ is that both are features of the plan serving the EQ objective and are only partly economically justifiable. The percentage of the total cost allocated to EQ is based on the study team's judgment and does not result from a particular allocation procedure.

6. Only rough estimates of the costs of the different actions are possible given the level of detail provided by the plans. For this reason the estimated cost is rounded tc reflect the level of accuracy to be expected at this level of analysis.

(continued on page 262)

PROGRAM SYNTHESIS: Estimated Cost of Short Term Water Supply Plan

Actions	Total Cost (Thousand Dollars)	Cost to NED Objective (Thousand Dollars)	Cost to EQ Objective (Thousand Dollars)
System Development			
. Exploration	300	300	
. Design Study	150	150	
. Construction	10,000	10,000	
. Energy (PV)	7,900	7,900	
Drip Irrigation			
. Installation & cost of irrigation system [3]	15,000	12,500	2,500 [2]
. Energy (PV)	350	350	
Investigations			
. Studies	1,300	900	400 [1]
Resolutions			
. State resolution to achieve minimum streamflow			
TOTAL	35,000	32,100	2,900

Notes:

(1) Half of the investigation on the effects of drip irrigation relates to environmental considerations.

(2) The drip irrigation system on 5000 acres of HC&S is necessary to achieve minimum streamflow requirements recommended by the fish and wildlife team.

(3) It is agreed upon between fish and wildlife and water supply to include the cost of the drip irrigation system (for achieving minimum streamflow) in the water supply plan even though the recommendation came from fish and wildlife. This is due to the nature of the cost and its direct relationship to the water supply plan.

7. In allocating NED cost for a Level B study it is the intent to follow in principle, the separable cost-remaining benefit method as described in the P&S, pages 140 through 155. This means that, to the extent possible, costs that can be attributed clearly to a particular functional area are to be separated out first. Subsequently the resulting joint cost is to be distributed among the functional areas. In the case of Level B studies this distribution has to be based on subjective judgment by study manager and study team because of the lack of detail in the plans. Judgment has to be exercised based on considering the relative advantages for each purpose of the proposed expenditures and associated actions. Thus rather than evaluating NED benefits for each purpose to arrive at a distribution of joint costs, consideration of the actions for which funds are expended provides the information to distribute joint costs. As illustrated the joint costs of pumping wastewater were shared equally by wastewater and water supply because after consideration of the specific actions involved, the study manager and the water supply team estimated that both purposes received equal benefits.

8. It is noted that the specific orientation of Phase 4 in terms of decisions and actions and the analysis of key implications facilitates exercising judgment with respect to cost sharing. It would be much more difficult if such judgment was needed on the basis of complete plans.

(continued on page 264)

PROGRAM SYNTHESIS: NED Cost Allocation of Short Term Plan

Actions	NED Cost ($1000)	Separable WS Cost ($1000)	Other Purpose ($1000)	Remaining Joint Cost ($1000)
System Development				
. Exploration	300	300		
. Design Study	150	150		
. Construction	10,000	10,000		
. Energy (PV)	7,900	6,300	--	1,600 WWM,WS (1)
Drip Irrigation				
. Installation & cost of irrigation systems	12,500	12,500		
. Energy (PV)	350	350		
Investigations				
. Studies	900	900		
TOTAL	32,100	30,500	--	1,600

Notes:

(1) Most NED costs were allocated to water supply, except part of the energy costs of source development (wastewater reuse) which are to be jointly shared by wastewater management. This is because pumping would be necessary for removal of waste from treatment plant as well as now for transporting wastewater to sugar cane fields. Therefore WWM and WS share pumping costs of wastewater reuse (1600) on a fifty-fifty basis.

9. The cost sharing of the proposed actions is only a first estimate so as to have some idea of the plan's implication for the different agencies and private groups. It is not intended to represent the final arrangements with respect to cost sharing.

PROGRAM SYNTHESIS: Estimated NED cost Sharing Arrangements*)

Actions	NED Cost ($1000) WS	NED Cost ($1000) Other	Federal	State	Local (County)	Private
System Development						
. Exploration	300		300-(u) (1)			
. Design Study	150			45 (d) (2)		80 (s)
. Construction	10,000				2,000 (3,4)	3,400 (s) 4,600 (r)
. Energy (PV)	7,100	800			1,900 (3,4)	3,600 (s) 2,400 (r)
Drip Irrigation						
. Installation & cost of irrigation system	12,500					12,500 (s)
. Energy (PV)	350					350 (s)
Investigations						
. Studies	900		200 (u)	350 (d)		350 (s)

Notes:

(1) Based on the expertise, long range interest and jurisdiction of USGS, exploration of high level and basal groundwater have been assigned to this Federal agency.

(2) The State (DOWALD) is contributing to the construction plans for the Lahaina water system.

(3) The County share includes all costs associated with design studies, construction and energy (PV) related to domestic water supply.

(4) In addition to the costs related to domestic water supply, included in these cost figures is a subsidy of 25% to the tourism industry of their share of construction and energy costs. The latter is based on rapid growth of developments in Kihei, the subsequent strain on the water supply system and the associated magnitude of the project.

*) u - USGS; d - DOWALD
s - sugar industry; r - resort development

IMPLEMENTATION OVERVIEW OF SHORT TERM DECISIONS

Actions	NED Costs		EQ Costs	Cost Sharing			
	Total WS ($1000)	Other Purposes ($1000)		Federal	State	Local	Private
System Development	17,550	800*	--	2%	<1%	22%	76%
Drip Irrigation	12,850	--	2,500	17%	--	--	83%
Investigations	900	--	400	21%	37%	--	42%
TOTAL	31,300	800	2,900	10%	1%	11%	78%

* Wastewater Management

PHASE 4

Summary of Short Term Decisions

Initial Presentation of Short Term Decisions

Public Response on Initial Presentation

Study Team Recommendations

Program Synthesis

→ Summary Level B Study

SUMMARY LEVEL B STUDY: provides the substantive information for the Executive Summary produced at the end of the Level B effort.

1. The Executive Summary is one of the key outputs of the total Level B study effort. Each individual study team has to summarize for inclusion in the Executive Summary their planning efforts. In order not to duplicate information presented elsewhere in this appendix, only an outline of the Executive Summary is presented, indicating the key questions that should be answered by the water supply study team with respect to their planning efforts on Maui.

2. The New Approach states: "The Executive Summary in the form of a brochure is intended for easy understanding by the public". This orientation makes the Executive Summary quite different from the Final Technical Report. In fact, the specific purpose in making the Summary Level B Study a separate output in the planning process is to have the study teams explicitly address the question: Of all the information generated during the study, what are the most important parts that should be communicated to the public?

3. In order to determine what should be communicated to the public, the study team needs to critically review its own effort and provide information on the basis of which the public can clearly see what tangible results were produced for the money spent on the study. Not only should such information help to bridge the credibility gap frequently encountered between planners and public, but more importantly it should demonstrate how the planning team has incorporated the feedback received from the public through the public involvement process.

(continued on page 270)

SUMMARY LEVEL B STUDY: Outline

The Summary Level B Study is designed to briefly and concisely communicate to the public the results of the water supply study team effort on Maui. It consists of five principal sections:

I Study Initiation
II Study Focus
III Study Results
IV Study Implications
V Study Implementation.

I. Study Initiation

Purpose: To convey to the public the type of problems, concerns and issues that were considered at the beginning of the Level B investigation.

Example: For the water supply effort on Maui problems were identified in five categories:

Demand:	Water demand projections (expected growth) for tourism and agriculture; effects of drip irrigation on agricultural land use and sugar production.
Supply Sources:	Impact of surface water rights and minimum streamflow requirements on water source development.
Demand/Supply Comparisons:	Study of economic and physical feasibility of seasonal storage and groundwater recharge.
Water Supply System:	Develop a "best" plan for water supply and recommend studies to determine appropriate parameters.
Institutional:	Given a "best" plan, develop implementation mechanisms for government and private interests.

II. Study Focus

Purpose: To convey to the public: (1) after a broad listing of problems, the study team narrowed the scope of their investigation to a set of specific study focuses; and (2) the type of questions addressed.

(continued on page 271)

4. It is emphasized that the different teams indicate what type of information should be communicated and not how or in what format. This information should be presented to the public. Once the inputs from the different study teams are presented to the study manager, he may use a variety of means to "package" it in a brochure. The important point is that substance preceeds format.

Focus 2

Assess impact of drip irrigation on agricultural land use and sugar production.

- What are the irrigation requirements under drip irrigation?
- How much is groundwater recharged and what is the recovery rate under furrow irrigation?
- What is the sugar production per acre under drip irrigation?

Focus 5

Develop "best" plan for water supply given uncertainty in basic parameters and recommend studies to determine appropriate parameters.

- What sources should be used (high level groundwater, basal groundwater, streamflow, wastewater, saline water, groundwater recharge)?
- How should sources be connected to demand?
- What problems need further investigation?

III. Study Results

Purpose: To convey to the public: (1) the recommendations of the study team for those problems selected as a focus for the study; (2) the type of problems not resolved by the study.

Example: For Focus 2: "Assess impact of drip irrigation on agricultural land use and sugar production" the study team developed a program of investigations that will assure that improved estimates on drip irrigation are available when plans for the period 1985-2000 need to be finalized. The study team did not make any improvements in the available estimates associated with drip irrigation.

IV. Study Implications

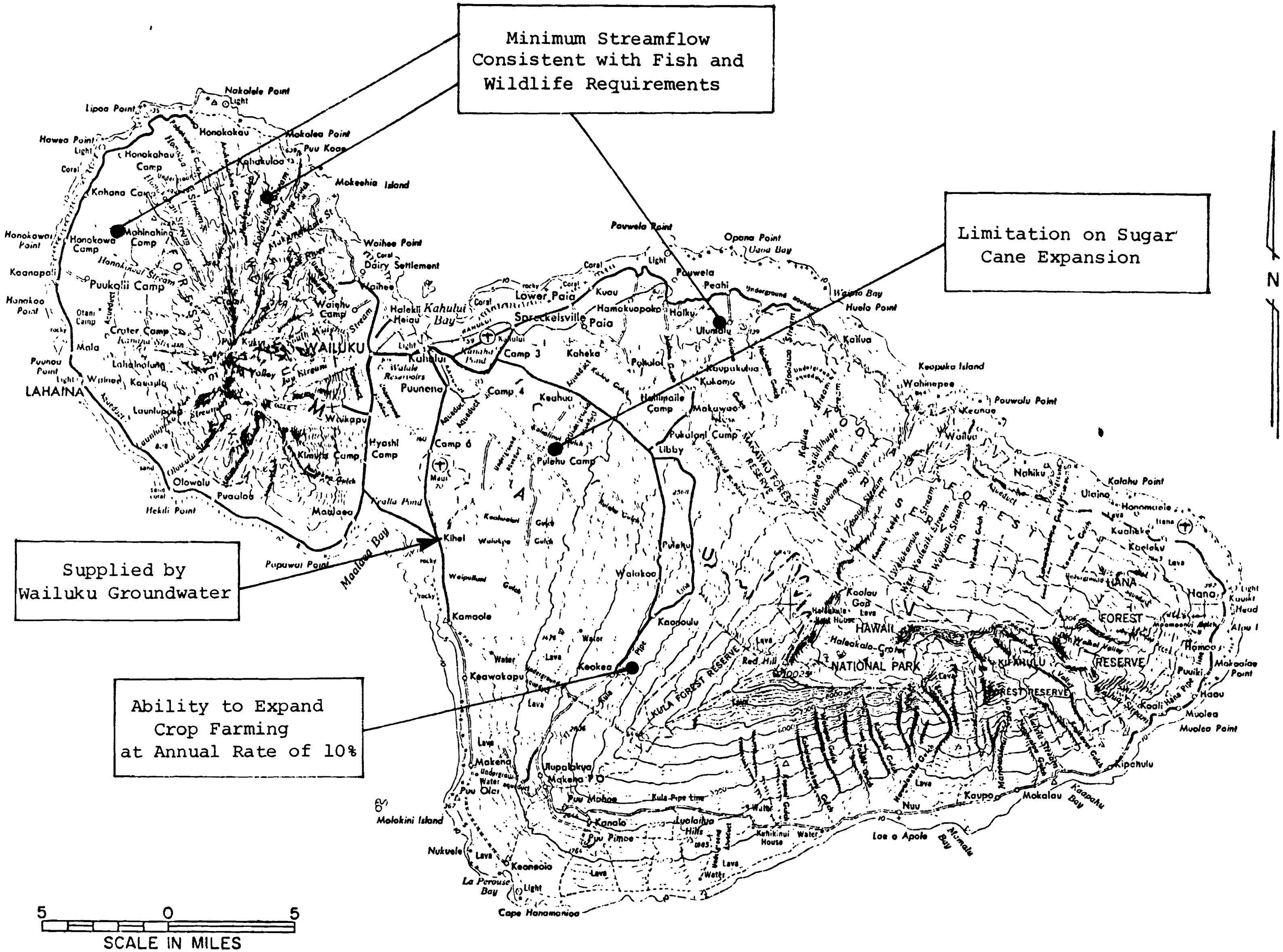
Purpose: To convey to the public the tangible outputs that will result from implementing the study.

Example: For Maui, the main implications for implementing the 1985 water supply plan are indicated on the map on page 273.

V. Study Implementation

Purpose: To convey to the public: (1) the cost associated with implementing the study team's recommendations; and (2) the institutional arrangements and type of projects necessary for the implementation.

(continued on page 275).



KEY IMPLICATIONS OF WATER SUPPLY PLAN FOR THE ISLAND OF MAUI

Example: The total cost of the Level B water supply plan is estimated at $35,000,000. These costs are to be shared between government and private sectors in the following proportions:

Participant	
. Federal	10%
. State	1%
. Local	11%
. Private	78%

The types of projects are summarized in the following table for the different Level B participants.

Participant	Projects
. Federal	. Environmentally oriented investigations; financial support for actions of the water supply system designed to enhance the environment.
. State	. Contributions to design studies for components of the water supply pland and future investigative studies.
. Local	. Planning, construction, and implementation of domestic water supply system; contribution toward private system development (plans) to facilitate further development of Maui.
. Private	. Planning, construction and installation of water supply system to support sugar and tourist industries.

The assignment of these actions to the various participants is based upon a combination of their (1) expertise, (2) legal authority and jurisdiction, and (3) interest in specific projects as they relate to their own missions.